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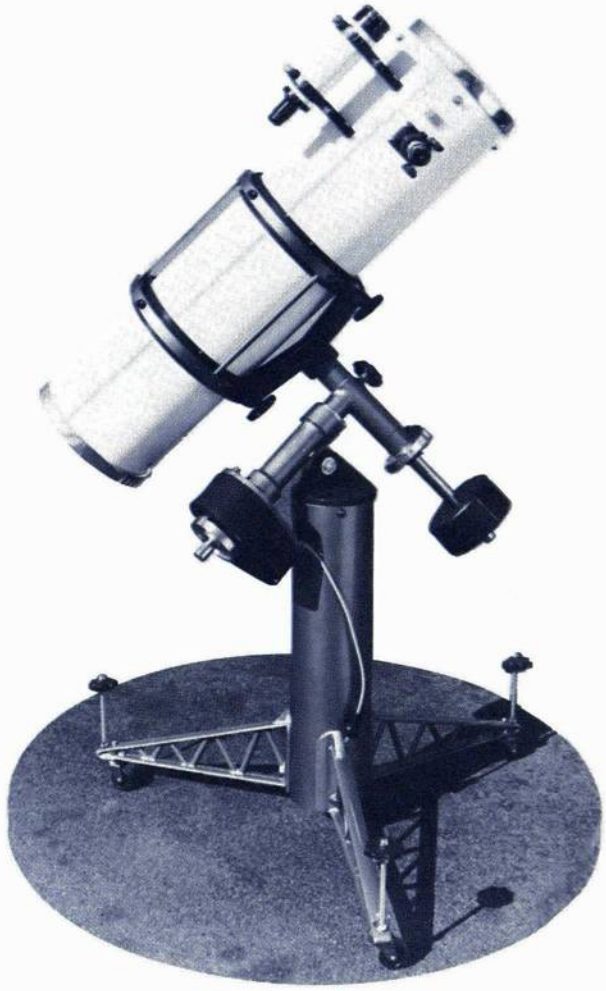

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November 1973 Vol. 1, No. 4

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Cover – Celestron photograph

By looking in the direction of the constellation Orion we are seeing one of the "dustiest" areas of the Milky Way galaxy. Here, in Orion's belt and sword, we find the star-producing emission nebula M-43 (lower) – the Great Nebula of Orion. Since astronomers know emission nebulae are the same approximate size from one spiral galaxy to another, they are able to determine galaxy distances by measuring nebulae diameters in other galaxies. See "Cosmic Dimensions" by Ronald C. Kroll and Terence Dickinson, which examines the method astronomers use to measure distances to the stars and galaxies.

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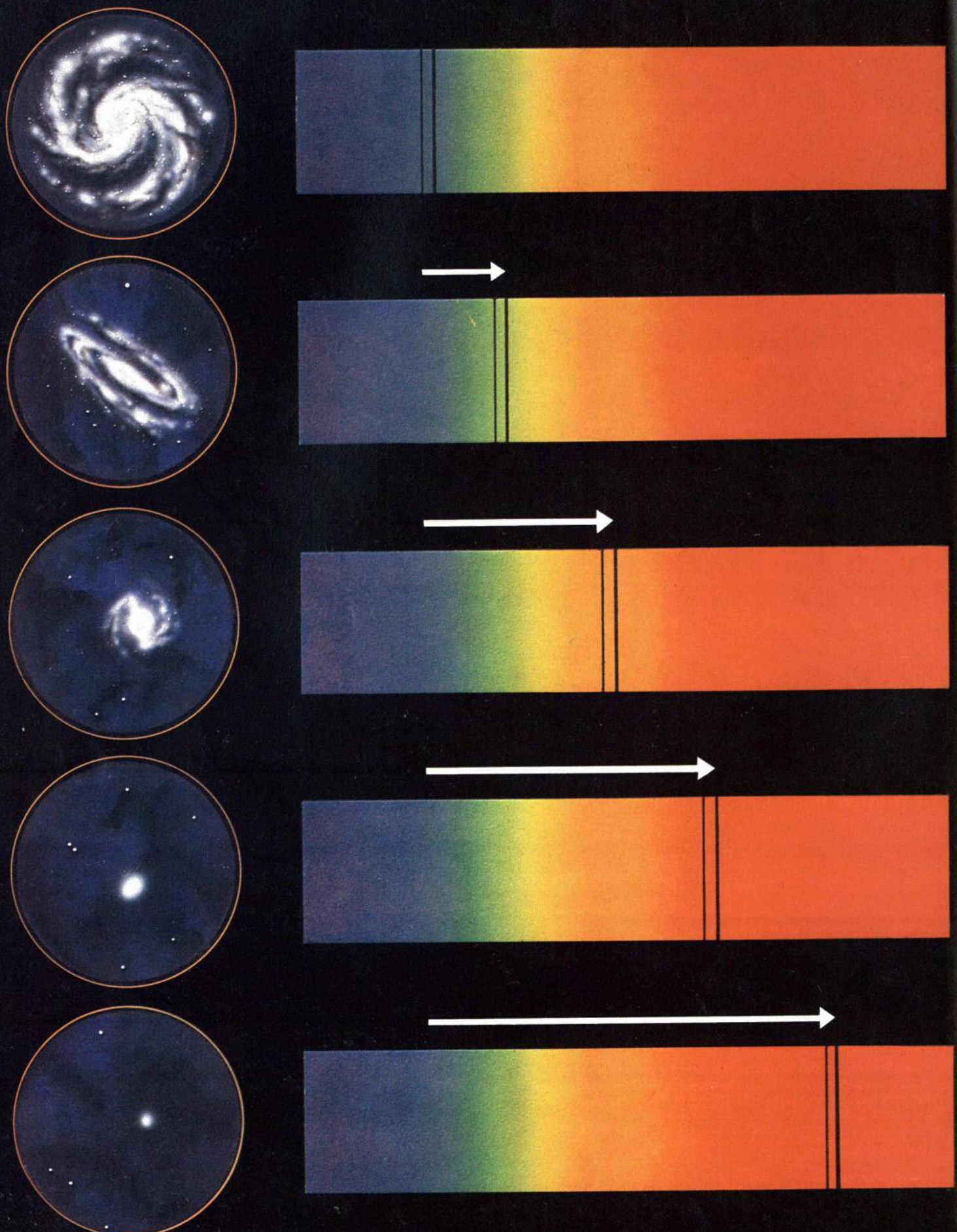


COSMIC DIMENSIONS

by
Ronald C. Kroll and Terence Dickinson

Since the dawn of human consciousness when man first looked to the sky and wondered about the objects that he could see there, a compelling series of questions must have been asked time and time again. "How far away are those lights in the sky; those unchanging, gleaming, twinkling points, the stars? Are the stars tiny lights suspended just beyond the clouds or are they holes in the fabric of the heavens?"

Such questions were asked and remained unanswered for countless centuries. Finally about 400 years ago, things began to change. The idea that our Earth is one of several planets orbiting around the sun became generally accepted. And with the invention of the telescope, the concept that the stars might be suns, like our sun, began to take root. And the question was asked again. How far away are they?

The more distant a galaxy, the farther its light is shifted to the red end of the spectrum. Redshift is noted by observing the galaxy's spectral "fingerprints" — the lines in the spectrum. The farther they are shifted from their normal positions, the faster the galaxy is moving away. This rapid recession causes a lengthening of the light waves producing the redshift effect. A simple rule of galaxies is: the farther, the faster.

Artwork by Victor Costanzo

Parallax

A way of determining stellar distances had been suggested long before by the Greek astronomer Aristotle. He said if Earth was in fact in motion around the sun, then the stars would appear to change their positions — the nearby ones seeming to move against the background of more distant stars as Earth moves in its orbit around the sun causing our viewpoint to change. Since such an effect was not observed by Aristotle, he concluded that Earth was not in motion around the sun.

Similarly, the great observer Tycho Brahe in the latter part of the 16th century made the same suggestion, only he observed with accurate naked eye sighting devices. And he too noted no apparent shifting of the stars. But since it was an inescapable conclusion after the early part of the

Hale Observatories Photograph

The outer regions of the Andromeda galaxy are resolved into stars in this photo taken with the 100 inch Mt. Wilson telescope. All the stars seen here are hundreds of times more luminous than the sun. Astronomers have detected dozens of Cepheid variables here. By taking a large number of similar photos and comparing them, the light variations can be followed — the key in determining the galaxy's distance.

17th century that Earth does in fact orbit around the sun, this predicted shifting of the stars — called parallax — must be there.

Parallax determination is a method of telescopic peek-a-boo that is essentially the same as the surveyor's method of finding distances to land-based objects. (See illustration on page 8.) If a surveyor needs to know the distance across a stream, he first measures off a base line along one bank. He then measures the angle formed by this base line and a tree or another target across the stream. By viewing from both ends of the base line, he can use basic trigonometry to determine the distance to the inaccessible tree and hence the width of the stream. The accuracy with which the surveyor can apply his measurements depends largely upon the length of his base line.

Astronomers applying this method to objects outside the solar system have no base line on Earth long enough to detect any shift of a star's position. However, Aristotle, Copernicus and Tycho Brahe all correctly argued that nearer stars ought to show a "stellar parallax" or periodic shift of position as Earth revolves annually about the sun in its orbit. A base line encompassing the entire width of Earth's orbit eventually proved to be long enough to do the job. (See illustration on page 10.)

Finally in 1838 Friedrich Bessel, at Konigsberg Observatory in Germany, using a heliometer (an instrument able to measure extremely

The Andromeda galaxy, a city of 250 million stars about two million light-years distant, is the nearest major galaxy to our solar system. Others are mere specks in all but the largest telescopes. The distance to this mammoth community of stars was determined by observing variable stars within it. Hale Observatories Photograph

Photograph copyright by the California Institute of Technology and Carnegie Institution of Washington

small sky angles with great accuracy) published the first measured parallax. The star was 61 Cygni, and Bessel's estimate of its distance was close to the current determination of 11 light-years (65 trillion miles).

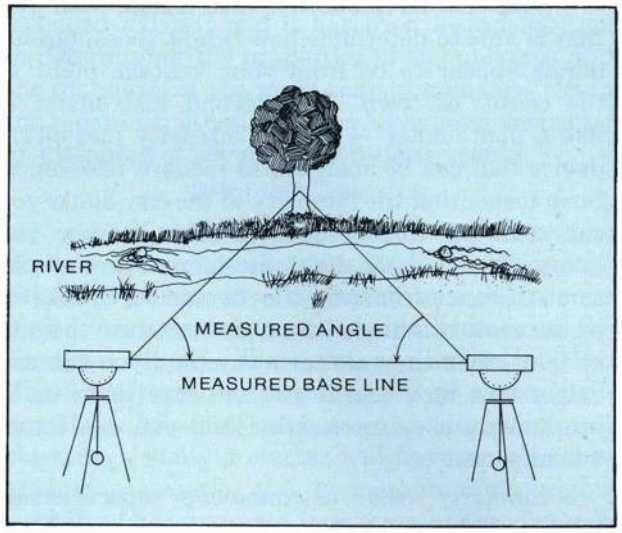
The late 1800s saw the end of the wet and insensitive collodion plate process of photography. A uniformly coated, dry emulsion on a gelatin base using silver salts was introduced, ten times more sensitive and considerably easier for astronomers to use and store. Positional astrophotography, or astrometry, soon became the most accurate and advantageous method of measuring the elusive parallactic zigzagging of the stars.

Although less than 30 angles of parallax had been measured by the late 1800s, today useful parallax measurements have been obtained for over 6,000 nearby stars. To continue the search for stars dimmer than the fifteenth magnitude, a 61 inch reflector was especially designed for photographing stellar parallaxes by the United States Naval Observatory station at Flagstaff, Ariz. Forty-five plates are exposed every year for two or three years. Stellar positions on these plates are then measured photometrically to an accuracy of one micron (a millionth of a meter). The motion of the suspected nearer star is determined, relative to the background of more distant stars. The astronomer makes further calculations to remove effects of proper motion (a star's motion at right angles to our line of sight) and the motion of the solar system. The stellar parallax remains.

The parallax of Alpha Centauri, the nearest known star beyond our sun, amounts to only slightly more than three-fourths of one second of arc in the sky. That's less than half the apparent distance between the two components of Castor, the well-known double star in Gemini. At 0.01 seconds of arc, even with automatic measuring machines, useful determinations of stellar parallax by trigonometric methods reach a practical limit. This takes us out to about 400 light-years. So stellar parallax really gives us quite an accurate picture of our own solar neighborhood. But distances to the rest of the observable universe are unobtainable by parallax. Less obvious methods evolved as the mind of man reached deeper into space.

Spectroscopic Parallax

In 1814 Joseph von Fraunhofer looked over



Surveyor's method of determining distances to inaccessable objects.

and over at dark bands in the sun's spectrum. He had spread sunlight into a wide "rainbow" with a coarse diffraction grating. Even at his untimely death 12 years later at age 39, these dark lines within the spectrum remained a puzzle to him.

We now know these lines are caused when continuous radiation from the heart of a star passes through cooler outer layers of the star. The cooler gases there absorb some of the emitted energy at specific wavelengths, and this absorption shows up as the dark lines — now known as absorption lines — in the star's spectrum. Each type of star has a characteristic series of these absorption lines as well as other distinctive features in its spectrum. Each particular spectral signature is noted as the astronomer classifies each star according to its temperature, size and luminosity class. Since the distances to the nearby stars are known by trigonometric parallax, once their spectral "fingerprints" are determined the next step is to compare their spectra to those of stars beyond 400 light-years. Let's use an earth-bound analogy to help explain this.

Suppose you're sitting on top of the tallest building in a small town. It's night; streetlights are on and so are the lights in the houses around you. Now assume you have a magic instrument that's able to determine the type of bulb in each street lamp and in each house. For example, it tells you that street lamps are 300 watts and it reveals that in one house there's a 100 watt lamp and in another 60 and so on. This is analogous to what the spectroscope does. Once a star is classified, its absolute brightness is known — like the wattage of a light bulb.

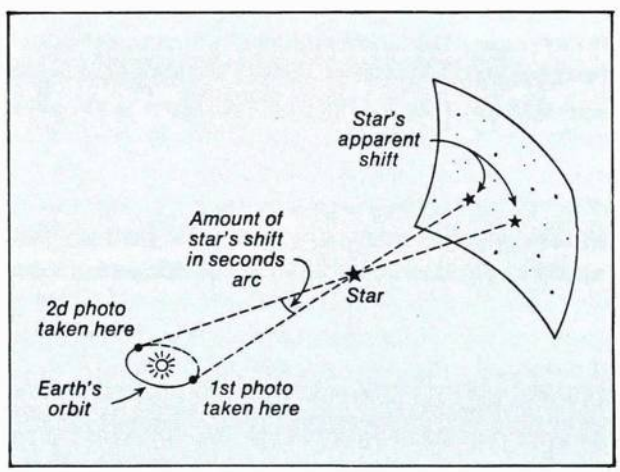
Colorful emmission nebulae are shown at left as reddish patches in the swirling arms of M-33. These star generating clouds of gas are similar in size from galaxy to galaxy. Because of this astronomers are able to measure distances to galaxies by measuring their angular size. Imagine — to a resident of M-33, the Great Nebula of Orion would only be a small reddish spot lost in a swirling myriad of stars.

You also have another instrument with you that is able to determine how bright these various lamps appear to be from your vantage point at the center of town. This second instrument is like a photometer — a light intensity measuring device that can be attached to modern telescopes. So in measuring the intensity of the city lights you can calculate the distance of each because you know that if all the 300 watt lamps were at the same distance from you they would all appear to be the same brightness. So if you measure them to be faint, then they are far away (and you can calculate how far), and if you measure them to be bright then they are nearby (and you can figure out how near).

Similarly the astronomer's spectroscope tells him what type of star he is looking at. Once the type is known he can easily calculate how bright it should be at any specific distance. He then measures how bright it appears to be and determines its distance — probably within 20 percent of its true distance. But there is a limitation with spectroscopic parallaxes. The method only works well with stars that are similar to the sun, that is, medium bright average stars. Giant stars, which can be seen at much greater distances, give astronomers more trouble because their properties are not as well-known. In general, spectroscopic parallax of stars is confined to our end of the Milky Way galaxy.

Cepheid Variables

There are certain stars that exist, as if by some cosmic design, to help man determine distances beyond his own galactic community to the other islands of stars in deep space. These are the Cepheid variable stars — giant superbrilliant stars that pulsate like colossal hearts, beating in a regular rhythm sending precisely timed waves of light to far beyond the edges of the galaxies in which they reside.



To obtain a star's parallax the astronomer photographs it at six month intervals, when Earth is at either side of its orbit. The diameter of Earth's orbit becomes the base line for calculating the dimensions of this cosmic triangle. The actual measuring is done using a highly sophisticated device that compares photographs of the star and its more distant neighbors. The shift is much less than shown in this diagram.

The Cepheid variables (pronounced see-fee-id) are on the average thousands of times brighter than the sun. Their similarity to hearts can be carried a step further. The brightest and biggest Cepheid variables pulsate the slowest with periods of several weeks. They can be compared to the hearts of elephants or horses. The fainter, smaller Cepheids pulsate more rapidly and can be compared to the more rapidly beating hearts of smaller animals like cats or squirrels.

So the pulsation period of a Cepheid is directly proportional to its brightness and size. This relationship has provided a magnificent yardstick in space because if we look at another galaxy — for example, the Andromeda galaxy — and observe the Cepheids there, we simply measure the length of their pulsation period. This tells us their true or absolute brightness. Then their apparent brightness is measured by a photometer. Comparing the absolute and apparent brightnesses gives their actual distances and hence the distance to the entire galaxy. Cepheid variables serve as beacons for measurements out to about four million light-years. This includes about 20 of our neighbor galaxies.

Gas Clouds and Brightest Stars

Although the Cepheid variables are brilliant stars, there are some that are still many times brighter. When observing galaxies beyond five million light-years it is only these extremely luminous stars that remain visible as individuals among the haze of their lesser companions. There is, however, an upper limit to the brightness of stars. None more than a million times as bright as the sun are known to exist. The superluminous stars at this limit form a rough guide in establishing the distance to a galaxy.

As a check on this astronomers measure the diameter of the nebulae in the spiral arms of these galaxies (see on page 7 .) It seems that the largest nebula in a galaxy is approximately the same size from one spiral galaxy to another. So by measuring this diameter we can then get a rough idea of the distance.

This double method — measuring the luminosity of the brightest stars in galaxies and measuring the diameter of the brightest nebulae in them — gives reasonable estimates of the distances to galaxies between 5 and 30 million light-years from us.

Redshifts

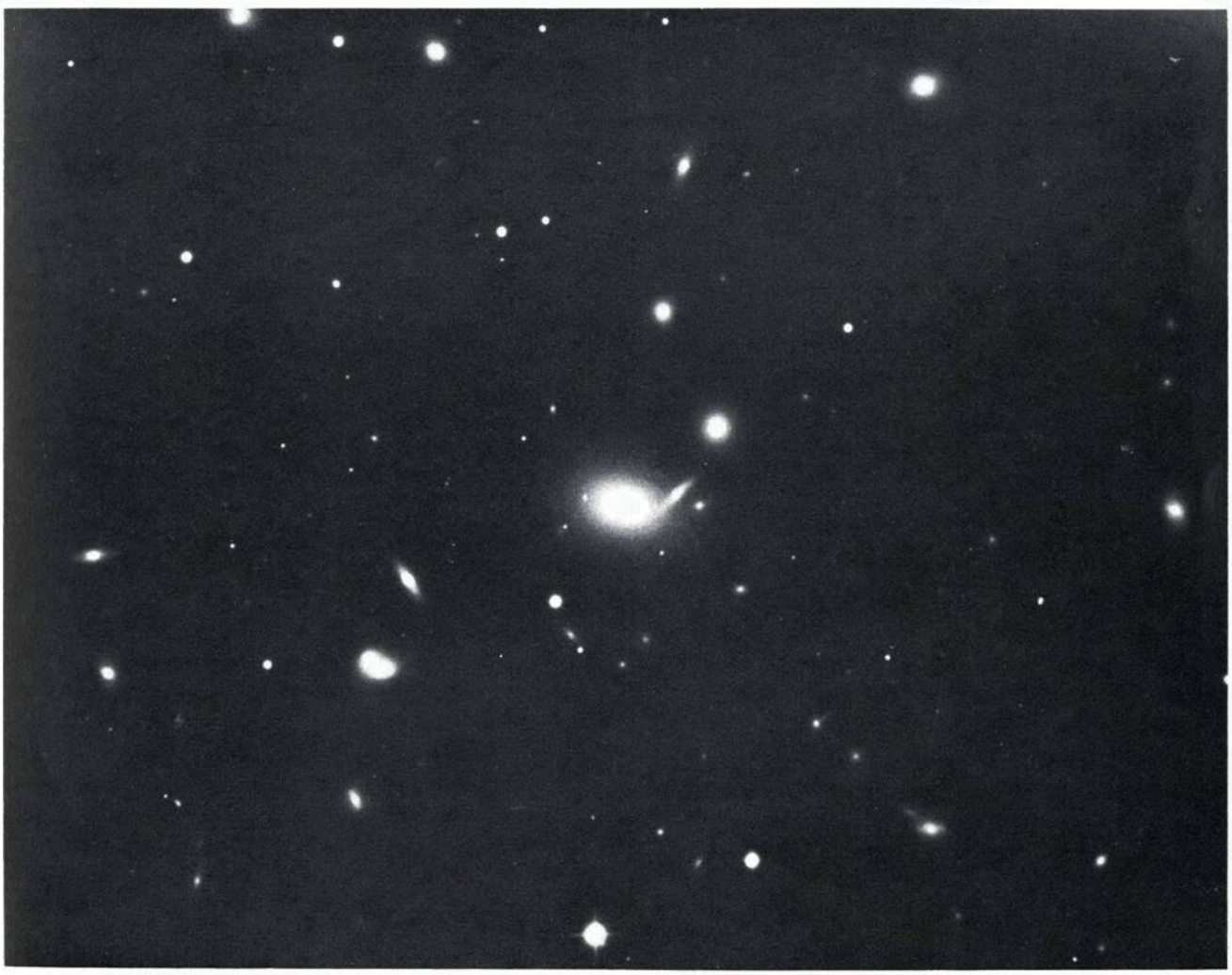
The absorption lines and other identifying

features of stellar spectra that were so useful in spectroscopic parallax determinations can also be used for galaxies. But the method is quite different.

One of the most important discoveries in the history of astronomy was the determination that the universe appears to be expanding. All the galaxies with the minor exception of a few of the very nearest) seem to be moving away from each other. And the farther away a galaxy is, the faster is its recession. This recession can be detected in a shifting of the lines in the spectra of galaxies; the farther the shift, the farther the galaxy. Just in the way the pitch of an auto horn is lowered as one listens to a receding car, the wavelength of the light from a distant and receding galaxy is lowered or reddened — shifted toward the red end of the spectrum. This is the so-called redshift and it has been a decisive tool in determining the properties of the universe and the distances of the most remote galaxies. Using the redshift method galaxies have been measured at distances of several billion light-years.

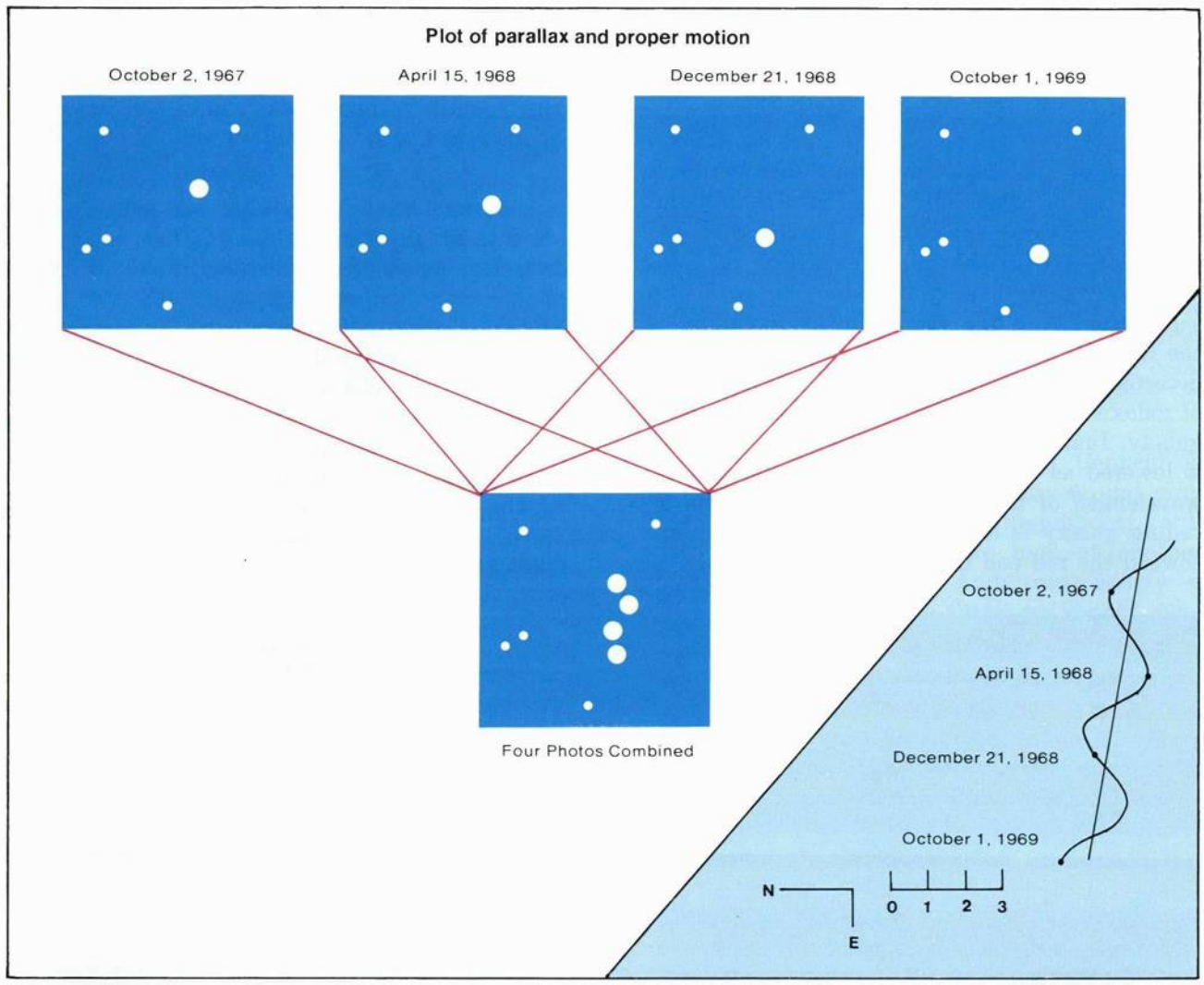
Brightest Galaxies

Just as the brightest star in a galaxy can be used to obtain the distance to that galaxy, the brightest galaxy in a cluster of galaxies can be used as a rough estimate of the distance to the cluster. Galaxies, like stars, are limited in size. The largest are immense swarms of several trillion stars. Also like stars, galaxies often appear in clusters. Usually a cluster will have one of these supergiant galaxies and the measure of its brightness is an approximate indication of the distance of the whole cluster of galaxies. Such clusters have been observed out to four or five billion light-years.



Hale Observatories Photograph

The spherical blob at the center of this photo is a giant elliptical galaxy containing at least a trillion stars. The galaxy's official designation is NGC 4889. Although only 13th magnitude, it is the brightest member of a cluster of about 1,000 galaxies, 300 million light-years away. The Coma Cluster galaxies had their distances estimated by the redshift method and by measuring the apparent magnitude of the brightest member.



Modern parallax determination utilizes a series of high resolution photographs usually taken with a long focus refractor telescope. Here, four hypothetical photos of Alpha Centauri are combined. In the combined picture the distant stars remain fixed while Alpha Centauri's image wanders for two reasons: (1) parallactic shift, and (2) proper motion — its actual motion across our line of sight.

The astronomer places the four images of Alpha Centauri on a zigzagging line — the result of parallax and proper motion. The deviation from a straight line is the parallax and its accurate measurement is used to determine the star's distance. Alpha Centauri has the largest parallax (but not the largest proper motion) since it is the nearest star. Parallaxes only two percent as great as this have been measured.

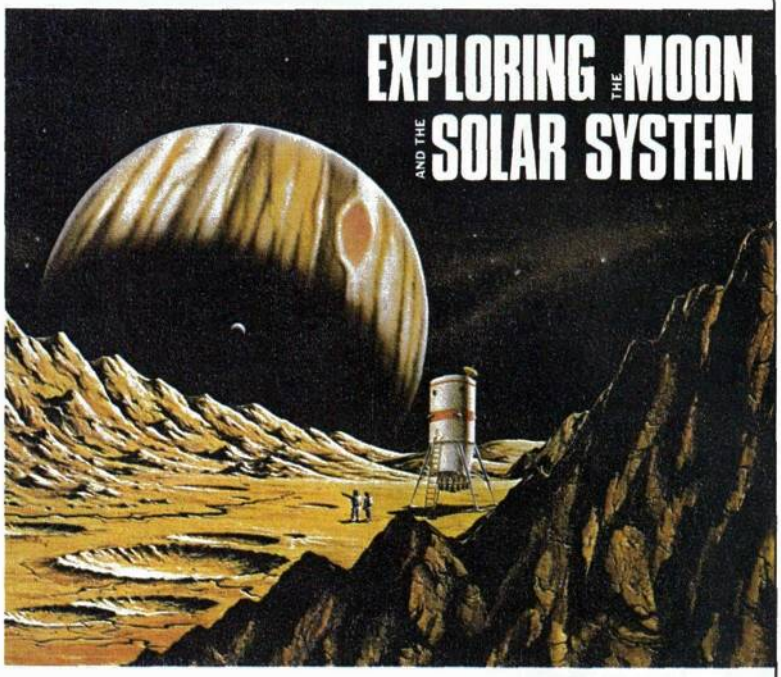
Quasars

Each mothod of distance determination has become less accurate as we have progressed to more remote sectors of the universe. Although there is some disagreement, most astronomers believe that the quasars are the most distant objects in the observable universe. They seem to be receding from us at velocities generally far greater than those of the most distant galaxies. Since the most distant galaxies are the fastest receding, if quasars recede faster they should be more distant.

Quasar OH471 recently had its redshift measured and is estimated to be receding from us at 91 percent of the velocity of light. This makes it the most distant object in the known universe. Estimates of its distance center around 10 billion light-years.

If in fact quasars are as far away as we think, then they represent a new and unknown phenomenon in the universe. They are ghostly images of the distant past — their light having taken billions of years to reach our eyes. The light that we see from them today left them billions of years ago when the universe was perhaps much different than it is today. The quasars probably do not represent the last link in this chain of cosmic distance-measuring methods. In the mind of man an understanding of more distant and more bizarre phenomena is surely just a few years away.

Exploring the Moon and the Solar System



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by

Frank Apsi

Of all the planets within reach of small telescopes, Mercury is certainly the most frustrating to observe. Although it approaches a neighborly 55 million miles from Earth (celestially speaking), its proximity to the sun nullifies any useful observations which might be made. Regrettably Mercury is forever veiled by the blinding rays of the sun and Earth's turbulent horizon atmosphere.

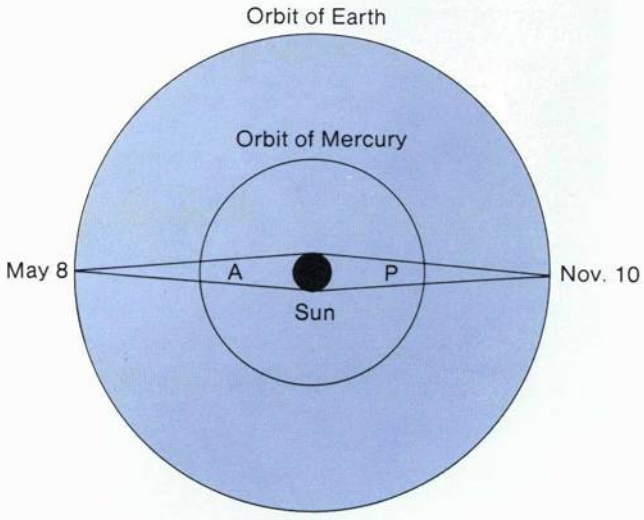
Since Mercury is never more than 26 degrees from the sun it must be observed during twilight as it hovers above the horizon. These conditions limit observations to short periods before sunrise or just after sunset — times that are indeed poor for observation. At best, Mercury is an indistinct orb merrily dancing about on swirling currents of air. At worst it is unobservable, completely obscured by the trees and buildings which conceal the true horizon. In fact, unless an observer is fortunate enough to have a clear view of the horizon, he may never have the opportunity to view this closest planet to the sun.

However, all is not lost — even for those who live in large cities where towering skyscrapers block out all but the zenith. The morning skies of November 10, 1973 will present the unique opportunity to observe Mercury in a rare display as this tiny planet makes a solitary trek across the face of the sun.

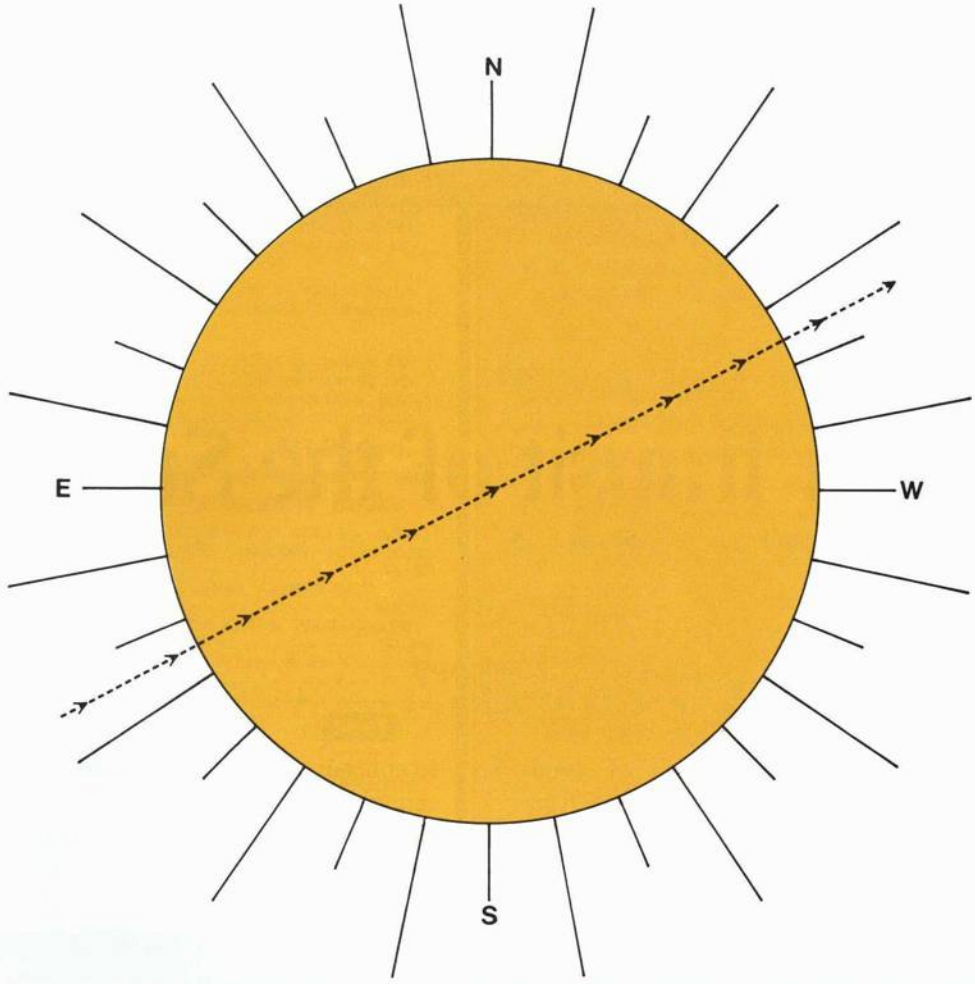
Transits

Transits occur when a planet is observed crossing the surface of the sun. A planet in transit, as viewed from Earth, appears in dark outline as it obscures a portion of the solar disk. If the angular size of the planet was sufficiently large to conceal the whole solar disk a unique planetary eclipse would result. However, there are no solar system residents with the requisite size for this to happen and so we must settle for the less spectacular transit event.

From Earth, only planets which lie inside its orbit — Mercury and Venus — are able to transit the sun. During the course of an inner planet's solar revolution, it is periodically aligned so that it is positioned directly between Earth



This exaggerated diagram shows why 70 percent of the transits of Mercury occur in November. Because of Mercury's eccentric orbit the May transits occur when the inner planet is far from the sun and those in November when it is near. Since there is more latitude in our angle of view to Mercury in November, the transits are most frequent then.



Photograph by Frank Apsi

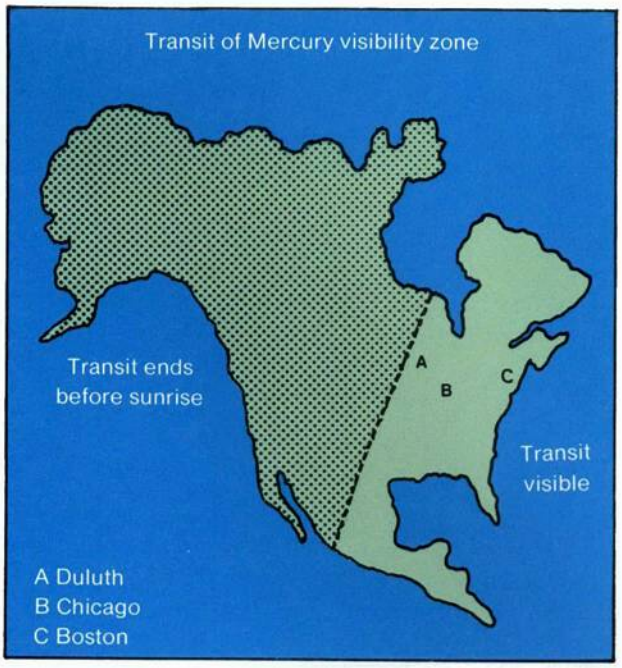
and the sun. Because the orbit of Mercury is inclined to Earth's orbit, most of the times when Earth, Mercury and the sun are approximately aligned, Mercury appears either above or below the sun. It is only on days around May 8 and November 10 that a transit of Mercury can occur, and of course Mercury has to be in the right place when Earth is in the right place in its orbit. (Mercury transits are more frequent in November for reasons explained in the diagrams.)

For this reason transits occur rather infrequently which makes them worthy of attention by professional and amateur astronomers. Only about a dozen transits of Mercury can occur in any given century. Venus is even more stingy, producing one or two transits per century with the next one not due until the year 2014.

Astronomers have long used transits of the sun to make important scientific studies of celestial objects which would otherwise have been impossible. During the 1800's scientists were able to study the atmosphere of Mercury during a transit. They reasoned that if Mercury had an extensive atmosphere, a detectable glowing ring would be produced when Mercury passed in front of the sun. When no such ring was viewed they correctly inferred that the atmosphere of Mercury was very tenuous or nonexistent. On the morning of April 20, 1910 a large number of anxious astronomers gathered to observe Halley's comet transit the sun. At that time little was known of the mass or density of comets and astronomers hoped to learn something of this by observing the size of the comet's nucleus as it was silhouetted against the sun. During the transit astronomers searched for the dark speck that would betray the comet's head, but could find no trace of it. It was completely invisible even in the largest telescopes, which indicated that Halley's comet, and comets in general, were nothing more than very loose conglomerations of matter.

This month Mercury will transit the sun on the 10th. Unfortunately the transit is scheduled to end at 8:17 a.m. EST (7:17 a.m. CST) when Mercury breaks contact with the sun's western limb. This will limit observation to areas in the continental United States where the sun is above

On the opposite page above is a diagram illustrating the path along which Mercury will traverse the sun's disk during the November 10 transit. This transit may be observed chiefly in the eastern United States immediately after sunrise. Below is a photograph of the May 1970 Mercury transit. The planet is at the lower left limb of the sun's disk and forms the point of an inverted triangle whose base is two sunspots. This photograph by Frank Apsi was made with a 3-1/ 2 inch reflector telescope.



Only eastern North American observers will have an opportunity to view the transit of Mercury across the sun on November 10, 1973. The transit ends at 8:18 a.m. EST.

the horizon at 13:17 Universal Time. Observers on the east coast will have the best opportunity to view the transit. Sunrise in Boston, for example is at 6:32, so the sun will be well up before the event ends. However, in Kansas City the sun will rise only 25 minutes before Mercury's exit.

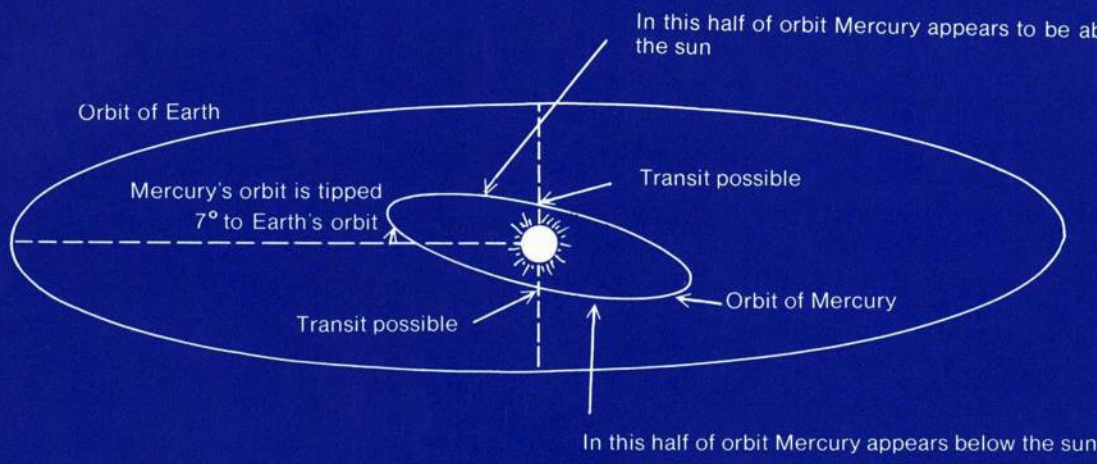
Those who are observing Mercury for the first time should not be disappointed by the dark featureless image this little world will present during the transit. Even when Mercury is viewed under the best of circumstances with the finest equipment, little can be seen in the way of surface detail. The best photographs and drawings made over the past 50 years reveal only patchy and ill defined regions with no discernable features.

A transit observation of Mercury will not only clearly show the disk of this planet but will also reveal its relative motion with the sun.

Observing Tips

Because the November 10 transit will end shortly after sunrise, observers should have their equipment set up before the sun's first rays break above the horizon. This will maximize the total viewing time available to an observer. The position of the sun at sunrise should be noted a day or two before the transit to insure that buildings and other obstructions near the horizon do not interfere with initial observations. This will allow time to select another observing site if necessary.

As soon as the sun is above the haze and


In this half of orbit Mercury appears to be above the sun
Orbit of Earth
Mercury's orbit is tipped 7° to Earth's orbit
Transit possible
Orbit of Mercury
Transit possible
In this half of orbit Mercury appears below the sun

Transits of Mercury are rare because there are only two small regions of the planet's orbit that intersect the plane of Earth's orbit. Only at these points can a transit take place.

Of course Earth has to be in the right place too. There are an average of 13 Mercury transits visible from Earth per century. The last one was in 1970, and the next is not due until 1986.

clouds of the horizon, look for a small black dot —darker than a sunspot — that looks like a bullet has been shot through the sun. It is quite small, only 1/200 the sun's diameter. In an inverting telescope, the dot will appear near the bottom of the solar disk. Telescopes as small as 60mm aperture will be sufficient to provide excellent views of the transit.

Carefully note the end phase of the transit. During the final moments Mercury will be in contact with the sun's western limb and will form a tiny black notch on the solar disk. As Mercury proceeds on its path the notch will continue to shrink in size until it disappears entirely, signaling the end of the transit.

Even though we are in a year of a "quiet sun", be alert for Mercury to coalesce with sunspots which lie in its path.

Observers who have equipment suitable for photographing sunspots will readily be able to record the transit. A series of photos taken several minutes apart will show the progression of Mercury across the sun's disk. Of special interest would be a photograph taken near the end of the transit while Mercury is sitting on the limb of the sun.

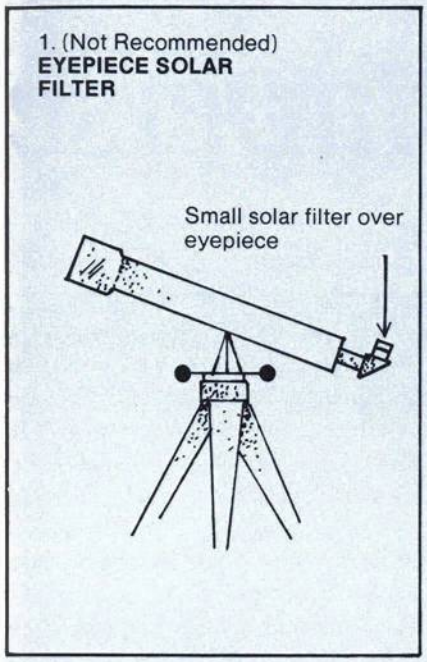
ASTRONOMY will be pleased to accept color or black and white photographs of this event for publication in future issues of the magazine. Payment for color photos is $10 and for black and white, $7.50.

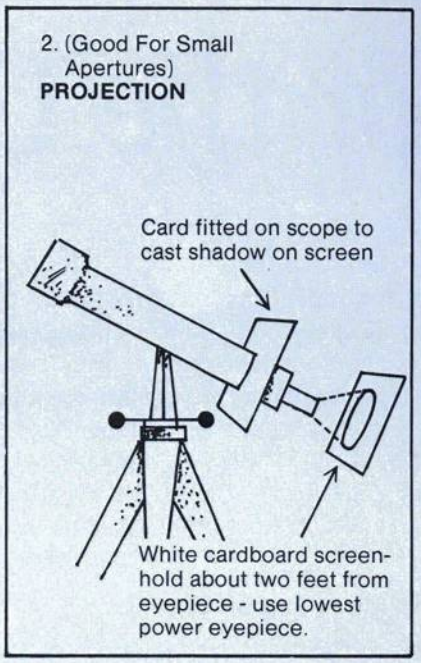
In summary, the morning skies of November 10 have much to offer astronomy enthusiasts. Mercury will put on a show guaranteed to please and delight as it performs its act in front of the blazing curtain of the sun.

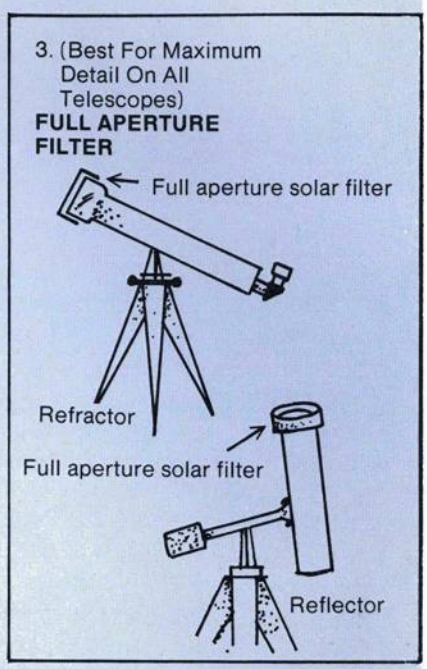
Remember, if you miss Mercury's unique celestial display this November you'll have to wait until 1986 before you get another chance to see it.

Observing the Sun With Your Telescope

by
Terence Dickinson




2. (Good For Small Apertures)
PROJECTION
Card fitted on scope to cast shadow on screen
White cardboard screen-hold about two feet from eyepiece - use lowest power eyepiece.



Most astronomy enthusiasts are familiar with the potential danger involved in viewing the sun. But if you are a novice observer, unfamiliar with the correct procedure, it is vital that you read this before viewing the transit of Mercury!

Never look at the sun through your telescope unless it is properly protected. Many small refractors come equipped with a small filter designed to be placed at either end of the eyepiece --either capped on the end closest to the eye, or screwed or clipped into the end closest to the objective lens. These filters are the least desirable method to use when observing the sun. They heat up very quickly because of the concentrated solar radiation near the focus of the telescope. After a very few minutes they will crack or melt allowing intense radiation to suddenly hit the eye of the observer. The editors of ASTRONOMY do **not** recommend the use of these eyepiece filters!

Inexpensive full aperture filters for use over the front of the telescope, before the light ever enters the lens (or in the case of a reflecting telescope, before the light goes down the tube) permit safe, direct viewing of detail on the sun. These filters reduce the sun's intensity to about 1/100,000 of its normal brightness. If you do not have such a filter or choose not to get one, the disk of the sun can be projected onto a screen thereby allowing its image to be viewed by the telescope operator and several onlookers.

If you own a commercially available 60mm refractor and choose to project the image of the sun don't use an orthoscopic eyepiece or any eyepiece that contains multiple lenses cemented together. The concentrated heat from the sun will damage expensive cemented eyepieces. The safest way to be sure that you are not using this type of eyepiece is to use your lowest power eyepiece which is almost invariably the simple noncemented two-element type. One drawback with the projection method is that the heat generated by large aperture telescopes (over six inches) becomes so great that something even brushing in front of the focus of the telescope is almost instantly set in flames.

Full aperture filters are available from $5 to $50 depending on size and type from Micro-Line Division of Bausch and Lomb, Box 938, Jamestown, N.Y. 14701, and Roger W. Tuthill, 11 Tanglewood Ln., Box 1086, Mountainside, N.J. 07092.

STELLAR FRONTIERS

Jewels of the Universe

by
Gerrit L. Verschuur

Everywhere swirling clouds of hydrogen gas and dust drift and stream through interstellar space. Sometimes stars are born in these clouds. When this happens, they heat up the remaining surrounding gas and produce a glowing cloud visible to us on Earth.

Let's abandon our vantage point on the surface of our planet and travel out to one of these incandescent gas clouds to see just what they are like close up. Forget for a moment, that nebulae such as the Orion, Trifid, Lagoon and Hourglass are so far away that they appear small in a telescope. Instead, let your imagination wander out toward them and see them as enormous, extremely hot clouds — breathtaking nebulae in which delicate, dynamic atomic processes are occurring.

Millions of years ago, a dense cloud of neutral hydrogen gas containing dust particles in profusion began to collapse slowly under the influence of its own gravity. Small pockets of dense material within the larger cloud began to collapse at a faster rate, heating up due to the pressure of gravitational collapse. These small pockets ultimately turned into protostars which grew very hot (1,000 degrees) and dense. Today, the remaining dense cloud of dust surrounding these "baby" stars does not allow their visible light to escape, but the infrared (heat) radiation can penetrate the dust; this is why we can detect protostars from Earth. One protostar is known to exist in the Orion nebula, and many other infrared sources have been found by astronomers surveying the sky with infrared telescopes located atop high mountains. Earth's atmosphere absorbs infrared radiation, so astronomers try to get above as much of the atmosphere as possible.

As our protostar grows even hotter and smaller, its radiation destroys or drives away the surrounding dust so that 100,000 years later, its light can escape out into space. A star we can see is thus born. Such a new star is often very hot and very large. We call them "O" or "B" stars, depending on their temperature and size. Most importantly, they radiate a tremendous amount of short wavelength ultraviolet (UV) radiation. (Astronomers use a spectral classification to categorize stars according to their temperature and mass. The broad categories are labeled O, B, A, F, G, K, M — "O" being the hottest, most massive, blue-white stars, and "M" being the coolest, least massive, reddish stars. Our sun falls in the middle — it is a yellow "G" star. To easily recall this code, just remember the phrase, "Oh, Be A fine Gal/Guy, Kiss Me!")

The UV radiation from the star encounters neutral hydrogen atoms in the gas cloud that surrounds it. When this happens, the radiation tears away electrons from the original hydrogen atoms. We then say that the hydrogen is ionized, and that the electrons are either moving entirely free of the protons, or are in very distant orbits about the protons.

When the electrons are knocked free, they rush through the gas cloud at many thousands of kilometers per second. These velocities are equivalent to temperatures of many thousands of degrees. UV radiation from the hot, young star is converted to energy in the gas cloud surrounding it. This is caused by the ionization of the

Several protostars are born simultaneously in huge interstellar gas clouds. As a result, beautiful emission nebulae, when photographed, exhibit a profound variety of shapes and sizes. Emission from the hot gas cloud itself is generally blue in color, while dust within the nebula — reflecting light from the protostars — tends to be red. The resulting color and patterns in the cloud are staggering beyond imagination as in the photograph at right of the Trifid Nebula located in the constellation Sagittarius.

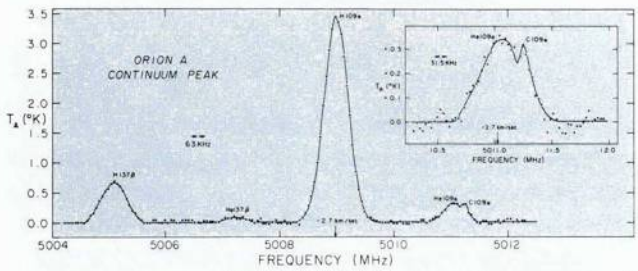
Photograph copyright by the California Institute of Technology and the Carnegie Institution of Washington

hydrogen atoms which effectively heats up the gas cloud.

As these free electrons hurtle through the cloud, they occasionally meet other electrons on similar wild paths. Such encounters cause the electrons to lose, or radiate away, some of their energy in the form of optical and radio electromagnetic waves. This is due to the fact that the electron is a charged particle which, when accelerated — that is, when it changes its state of uniform motion — will generate an electromagnetic wave. The fact that signals are generated over the entire electromagnetic spectrum, from visible light to radio waves, is due to the existence of an enormous number of electrons being involved in this process simultaneously. Encounters between the electrons can take on a whole range of values, from direct collisions to very distant, weak interactions. The density of the gas cloud determines the frequency of such electron encounters, and the frequency and nature of the encounters between electrons determines the range of wavelengths radiated and the intensity of the signals emitted.

Let's look closely at the region around one of the hot stars that has just been born in the larger cloud. Imagine the star to be just in front of you, and imagine that the gas cloud surrounding it is perfectly uniform in density. UV photons emitted from the young star first encounter and then ionize neutral hydrogen atoms in the star's immediate vicinity. Photons that follow are free to move unhindered through the already ionized material. When the photons finally encounter and ionize atoms, they are absorbed and not able to ionize any further material. This process continues outward through the cloud to greater and greater distances from the star.

However, the process does not continue indefinitely — a counterbalancing effect also takes place. Electrons and protons are recombined to form hydrogen atoms which may, once again, be ionized by UV photons. A point of balance is reached where the ionization and recombination are equal. It is at this point that the sphere of ionized matter around the star becomes no larger. Recombinations inside this sphere produce enough additional atoms to absorb all the UV radiation emitted by the star in a given volume of space.



National Radio Astronomy Observatory Graph

The above graph illustrates a set of radio recombination lines observed with a radio telescope pointed at the Great Nebula in Orion. The inset shows an enlarged version of the weak lines on the right side of the graph. Recombination lines occur when electrons orbiting hydrogen (H) and helium (He) atoms change their orbits to lower energy states (when the electrons move closer to their parent nuclei). A carbon (C) recombination line is also visible.

The Danish astronomer Bengt Strömgren was the first to work on a detailed theory of this process, and the ionized sphere of matter surrounding a star located in a uniform gas cloud is referred to as the Strömgren sphere. The radius of the sphere is dependent both on how many atoms are capable of absorbing the UV radiation, and on the temperature or UV output of the star. For "O" stars, the radius of a typical cloud can be tens of light-years, while for a star like the sun it may be extremely small (fractions of a light-year).

Nature does not usually produce single stars in uniform clouds of gas. Clouds will have considerable density variations within them, and usually many stars are born simultaneously in such a cloud. For this reason, emission nebulae photographed from Earth show all sorts of beautiful shapes and sizes — shapes and sizes that depend on the structure that exists within the cloud in which the stars are located. The emission from the hot gas is generally blue in color, while the starlight reflected from the dust within and around the nebula tends to be red. The resulting color patterns in a nebula can be quite staggering in their beauty.

How can we be certain that recombination of the electrons and protons is really occurring? Well, we can observe these recombinations directly because of the radio signals that are emitted during recombination.

When an electron drops into an orbit closer to the proton, we find that the atom's total energy is less. In the case of hydrogen atoms, this energy difference can be radiated away from the atom as a radio signal. When the electrons drop from the highest orbit to the next lowest, energy emissions are in radio frequencies. Each change in level involves radiation at one frequency only, thus producing a discrete spectral line. Changes in orbit at the lowest levels are visible at optical wavelengths, producing spectral lines such as the well-known Hydrogen Alpha line. Recombining hydrogen atoms produce about 200 spectral lines between radio wavelengths of 1 and 75 centimeters.

Study of the recombination line shapes and

Kitt Peak National Observatory Photograph

The above photograph of the Lagoon Nebula in Sagittarius illustrates the variety of detail that exists in an emission nebula. Dark blobs of obscuring dust in the gas cloud show wisps of bright material radiating toward the ionizing protostars. Long tongues of dark material projected against a bright background and pointing directly away from the nearby ionizing star are referred to as "elephant trunks" because of their distinctive appearance.

intensities, as compared with the so-called continuum emission which covers all optical radio wavelengths, enables the astronomer to derive information about a gas cloud's temperatures and densities. On the other hand, study of the frequencies of the observed lines as compared with the expected values allows him to determine the atom's motions within the nebula. A shift in frequency is produced by motion in the cloud as a result of the Doppler effect.

When we look at a photograph of an emission nebula, such as the Lagoon nebula in Sagittarius, we often see dark blobs projected on a brighter background. Some of these dark blobs show wisps of bright material radiating toward the ionizing stars. These dark blobs are very dense dust clouds into which the ionizing UV radiation can not penetrate. However, the surface layers are very slowly being worn away and may stream out from the dense dust "globule" and stream toward the less dense region of space around the hot stars. In some cases, the dust cloud is very small and sufficiently dense to produce a shadowing effect on matter more distant from the ionizing stars. One then sees a long tongue of dark material projected against a bright background, with the tongue pointing directly away from the nearby ionizing star. Such objects are often referred to as elephant trunks because of their distinctive appearance.

All these dynamic processes and others occur in such jewels in the sky as the Orion, Lagoon and Trifid nebulae. Next time you look at one of these objects with the naked eye or telescope, try to picture it up close. Imagine the delicate balance between ionization and recombination which determines its detailed appearance. Think of the numerous spectral lines radiating toward us that indicate the recombination, not only of the hydrogen atoms, but also helium and ionized carbon. And try to imagine the enormous extent and great temperatures that exist in these regions of space, where stars are still being born.

AUTHORS

Gerrit L. Verschuur — Dr. Verschuur is currently director of the Fiske Planetarium and a professor in the department of astrogeophysics, both at the University of Colorado in Boulder.

He received his Ph.D in 1965 from the University of Manchester in England, following several years of work at the Nuffield Radio Astronomy Labs. He remained at the university — on the faculty — until 1967 when he came to the United States.

Upon arrival in this country, Dr. Verschuur joined the staff at the National Radio Astronomy Observatory in Charlottesville, Va. He remained there, in various capacities ranging from research associate to associate scientist, until 1973.

In addition to 52 published scientific papers, he has contributed an article, "The Interstellar Medium", to the 1973-74 edition of **Encyclopaedia Brittanica.**

Dr. Verschuur is the co-editor of a textbook, **Galactic and Extra-Galactic Radio Astronomy**, and the author of **The Invisible Universe**, a layman's introduction to radio astronomy. Both books are scheduled to be published around the first of the year by Springer-Verlag New York, Inc.

Frank Apsi — An aerospace engineering consultant, Mr. Apsi received his B.A. in systems engineering from Brooklyn Polytechnic Institute, and his masters in the same field from Rensselaer Polytechnic Institute in Troy, N.Y.

Mr. Apsi first became interested in astronomy at the age of six when he saw an "unforgettable show" at the Hayden Planetarium in New York. He has since helped organize the Manchester Astronomical Society. (According to Mr. Apsi, the members of the M.A.S. have collectively purchased a 12 inch reflector telescope, much like members of a flying club might collectively buy a plane.)

Mr. Apsi has written numerous articles which have appeared in astronomy-related publications, and has also had several science fiction short stories published under a pseudonym. Among his published technical papers is an article discussing the engineering aspects of the Mariner 4 spacecraft.

Victor A. Costanzo, Jr. — ASTRONOMY is pleased to announce the addition of Mr. Constanzo to the staff as contributing artist.

Mr. Costanzo has been chief production designer at the Strasenburgh Planetarium of the Rochester Museum and Science Center in Rochester, N.Y. since 1967. He came to the planetarium after receiving his M.A. in graphic design from the Rochester Institute of Technology.

One of the world's leading astronomy illustrators, Mr. Costanzo's artwork is displayed in many planetariums around the world. The accuracy and content of his work is due in part to his lifelong hobby of astronomy.

Ronald C. Kroll — A resident of Indianapolis, Ind., Mr. Kroll is presently engaged in a statistical study of repetitive planetary phenomena such as conjuntions, transits, and oppositions.

He first became interested in astronomy in 1959 as an amateur, observing comets, eclipses and occultations, and in 1962 began experimenting with planetary photography. Subsequently, he constructed a six inch, f/15 refracting telescope which was designed specifically for planetary and color photography with cooled emulsion cameras.

Mr. Kroll has also lectured in Stevens Point, Wis., where he presented a research paper on the Hertzsprung-Russell diagram.

Craig McFarland Brown — Mr. Brown, art director of ASTRONOMY, is responsible for the graphic layout and design of the magazine.

A graduate of the Layton School of Art in Milwaukee, Wis., he received his M.S. in visual communications in 1973 from the University of Wisconsin — Milwaukee.

Mr. Brown was previously employed as an artist by the American Greetings Corp. in Cleveland, Ohio. He has also taught oil painting to adult evening classes at the Milwaukee Area Technical College.

R. Newton Mayall — Mr. Mayall is an engineer and noted amateur astronomer. His wife, Margaret, is a professional astronomer and Director of the American Association of Variable Star Observers (AAVSO).

Together and singly, the Mayalls have written many books on astronomy and related subjects. Mr. Mayall has also contributed to several encyclopedias and national magazines. He is a member of the AAVSO and the Royal Astronomical Society of Canada.

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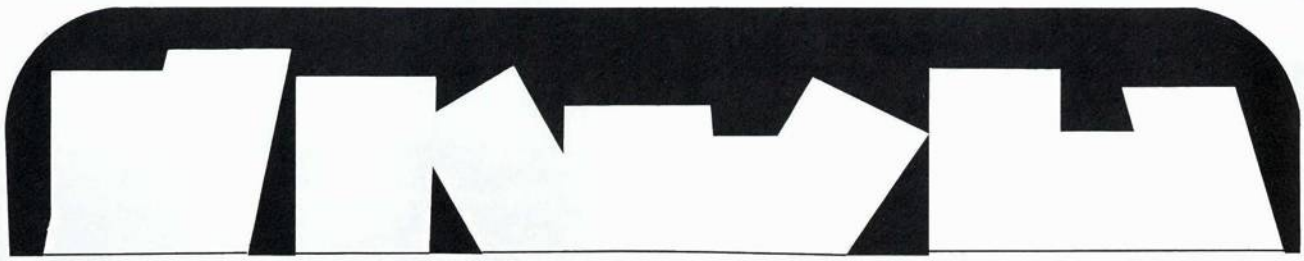


LETTERS TO EDITOR

Sir / I observed with great interest the recent shadow transits of Io, Europa, and Ganymede predicted by Terence Dickinson in September's Sky Almanac. Using a six inch reflector at 150x, I was able to detect the shadow of Io on September 1 within five minutes of the predicted beginning of the transit, and the following evening the shadow of Ganymede was clearly visible even to guests of mine who were not used to looking through a telescope. I was somewhat disappointed, however, with Europa, whose shadow was also in transit at the same time. Although cast between two equatorial cloud belts, I found this shadow much more difficult to see and hard to distinguish from a possible surface feature of Jupiter. Some of my guests could not see it at all and others were at best skeptical.

I thought that perhaps the varying sizes of the different moons and their distances from Jupiter might substantially affect the size of the penumbral and umbral shadows they cast, and thus affect the visibility of the transits. In **Celestial Objects for Common Telescopes**, Webb states that Jupiter is so far from the sun that the shadows cast by the moons are almost as large as the moons themselves, and so are plainly visible, while, of course, a shadow transit of our moon (as seen from Jupiter) would be very difficult indeed because of the very small umbral shadow cast.

Not convinced, I prepared the following table that compares the lengths and sizes of the shadows of the four Galilean satellites. I assume that the shadows fall on the center of Jupiter's disk.

Satellite	Dia.	Dist. from Jupiter	Length of Shadow	Size of Shadow (on Jupiter)
Io	2,020	262,000	1,130,000	1,560
Europa	1,790	417,000	1,000,000	1,040
Ganymede	3,120	664,000	1,750,000	1,940
Callisto	2,970	1,170,000	1,660,000	880

(all distances in miles)

This data clearly suggests why Europa's shadow might be more difficult that Io's or Ganymede's. Europa's shadow size is considerably smaller. I suspect that the varying sizes of the penumbral shadow (larger for the moons farther from Jupiter) would also have an effect — making the darker shadow more or less distinct on Jupiter's disk.

If my data and reasoning are correct, it would appear that the shadow transit of Callisto later this month will be even more difficult in a small telescope. Isn't Mr. Dickinson being a bit optimistic when he writes that shadows are "easy in a four inch telescope"?

THOMAS C. BRETL,
Oconomowoc, Wis.

Mr. Bretl / We think an overall point that you make, without actually stating it, is that Jupiter and its moons make fascinating targets for the amateur observer.

In hundreds of hours of observing Jupiter, we have never noticed any difference in the size or distinctness of the shadows of the Jovian moons. However, we were not looking for any either. In examining our observing logs, we noticed only one entry when two shadows (Io and Europa) were seen at the same time. Our drawings show them appearing the same size, as viewed through a seven inch refractor.

We have found the shadows of Io, Europa and Ganymede easily with a three inch refractor in average seeing. We have, however, never observed Jupiter during the predicted presence of the shadow of Callisto which according to your table should be the most difficult.

The varying difficulty in observing the shadows of Jupiter's satellites is now going to be a personal project of ours, and we hope other amateurs will try as well. Can any of the shadows be seen in a 2.4 inch refractor or a three inch reflector? If so, which ones? What about Callisto's in a three inch refractor or four inch reflector? Or are larger apertures required? Can the shadows be followed to the edge of Jupiter's disk?

Our thanks to you for raising an excellent point that, to our knowledge, has not been discussed before in astronomy publications.

Sir / Wm. Bruce Weaver's coverage of the search for the 10th planet in your first issue prompts me to make two suggestions which seem to have been ignored in all accounts of Planet X I've seen so far. The first concerns the planet's origin. If X is found to be the nonconformist predicted — larger than Jupiter, inclined to 60 degrees to the

plane of the ecliptic and in retrograde motion — isn't it likely that it is an adopted wanderer from interstellar space rather than a bona fide member of the solar family? Support for such a theory can be found in Harlow Shapley's essay "Life Among the Dwarfs" in **Beyond the Observatory**. Shapley suggests that what he calls "detached" planets may even outnumber the stars themselves, so perhaps the chances of our sun having captured one is not so remote as it first seems.

My second suggestion concerns the naming of Planet X when it is found. The final selection of a name must be left up to the discoverer, of course, but I would like to suggest for openers that serious consideration be given to Janus, the Roman god of doors and of beginnings and endings. The tenth planet, after all, may well become our door to the universe and come to symbolize a boundary line which marks the end of the solar system and the beginning of interstellar space. And if Planet X is found to be an adopted planet as I suggested above it would be especially appropriate to name it after the god of traffic who was traditionally depicted with two faces, one looking forward and the other looking back.

NEAL WILGUS,
Corrales, N.M.

Mr. Wilgus / Thank you for sharing your thoughts with us.

Sir / I would like to draw your attention to page 38 of the October 1973 issue of ASTRONOMY. There, at the top of the page, is an excellent photograph of what is reported to be " ... M-43 in Orion." I feel it my duty as an experienced deep sky observer and writer to point out to you that this photograph is not of M-43, but rather the diffuse nebula north of M-43, NGC 1977. To prove my objection, these are the positions for the three nebulae involved in this area:

NGC 1976 (M-42) $05^h\ 32.9^m$, $-05°\ 25'$
NGC 1977 $05^h\ 33.0^m$, $-04°\ 54'$
NGC 1982 (M-43) $05^h\ 33.1^m$, $-05°\ 18'$

An examination of the declinations will show that M-43 is located in between the other two nebulae. Further, a comparison with any wide angle photograph of this region will also show that M-43 does not look anything at all like the photograph in your magazine. The photograph is, indeed, of the diffuse nebula NGC 1977. I find it rather surprising that such an error would be published in your magazine.

JOHN I. RIGGS,
Kenmore, N.Y.

Mr. Riggs / We are certain purists in ASTRONOMY's audience will appreciate this information. Thank you very much.

Sir / I received Volume 1, Number 1 of your new magazine, ASTRONOMY, yesterday and I would like to compliment you on an outstanding new magazine which I am sure will be as much of a success as you might have hoped. I think it's the kind of magazine which would sell on newsstands and be appreciated by the amateur no matter what stage of development he might be in.

I have a constructive criticism, however. Since you do feel that your magazine is the most beautiful astronomy magazine in the world, I would suggest that you mail them in the future with paper wrappers to protect the issues because mine arrived from the United States Postal Service in an almost unreadable condition.

I hope that the criticism has not shadowed my true feelings about the excellence of your magazine.

GERALD E. BUTLER, M.D.,
Ann Arbor, Mich.

Dr. Butler / You will note that we are indeed now mailing ASTRONOMY in wrappers to protect it from the ravages of the Post Office. We hope our readers will continue to notify us of such problems.

Sir / I am returning a portion of your mailing jacket which I received with your second issue of ASTRONOMY. On the mailing jacket you requested to know of any delays in mail service, so I am writing to advise you of such poor service.

My first issue of ASTRONOMY (August 1973) arrived without a mailing jacket and in very bad condition. As I am very interested in ASTRONOMY, and will remain one of your subscribers I was extremely disappointed in the damage done to my original issue. The poor postal service continued with the late arrival of the second issue — mailed on Aug. 17, 1973, it arrived on Sept. 4, 1973.

This letter is to advise you of the above mentioned poor postal service and to request that — if it is at all possible — you send me a replacement copy of the August 1973 issue. I would appreciate it very much!

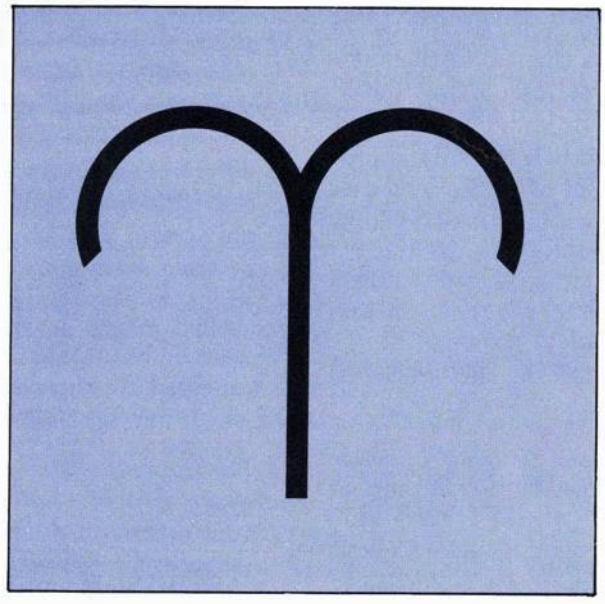
Thank you very much for publishing such a fine magazine dealing with the various fields of astronomy.

BOB JACOBSON,
So. Lake Tahoe, Calif.

Mr. Jacobson / By now you should have received your replacement copy of the August 1973 issue of ASTRONOMY. We will send replacement copies of the August issue to our readers upon request. And if our readers return their damaged copies to us, we're sure it will aid us in our continuing battle with the Post Office.

CONSTELLATION CLOSE-UP

aries



by

Thomas C. Bretl

Compared to Pisces preceding it, Aries the Ram is a "tiny" constellation. It is comfortably nestled among many famous sky objects. If its boundaries were extended just three degrees to the west, M-74 would fall within its territory. Stretch its boundaries a mere five degrees to the east, and the Pleiades would certainly become its star attraction. Not far to the south lies the constellation Cetus and Mira, "the wonderful", to the north lies Triangulum and M-33.

In the midst of these wealthy neighbors, Aries itself contains many interesting, if less familiar, telescopic objects. Can you think of any? No? Well, don't reach for your star atlas or turn to this month's table of double stars and galaxies. Try something different: turn to Aries!

Aries is a small constellation - a good place

to try some "sweeping". With no preconceived ideas about double star colors or the positions of nebulae, but with the knowledge that at any moment something of beauty may float silently across your field of view, you will experience a whole new kind of observing excitement - one filled with anticipation.

A good place to start is in the area around the prominent triangular pattern formed by Alpha, Beta, and Gamma Arietis - an asterism which is actually situated near the western edge of the constellation. Use a low power eyepiece with wide field of view and sweep north and south along lines of right ascension. Then slowly move eastward, one field diameter at a time, across the constellation. Be alert for any "fuzzy spots" and try greater magnification on any stars that hint of being double. Try it, and see what you can find!

Did you notice the differences between Alpha, Beta, and Gamma, the three stars forming the triangle? Hamal, Alpha Arietis, is obviously brightest (magnitude 2.2) and has a definite orange color. Its spectral type is K, the same as Arcturus. On the other hand, Sheratan and Mesarthim (Beta and Gamma) are both white, type A stars. They are in the same class as Altair. Hamal, at a distance of 76 light-years, and

TABLE OF OBJECTS IN ARIES

Double Stars

Star	Magnitudes	Sep.	Colors	R.A.	Dec.
1	6.2 — 7.4	2.8"	Gold-blue	1^h48^m	+22°08'
γ	4.8 — 4.8	8.2"	White-gray	1^h52^m	+19°09'
λ	4.8 — 7.4	37.4"	White-blue	1^h56^m	+23°16'
30	6.6 — 7.4	38.7"	Gray-yellow	2^h35^m	+24°38'
33	5.4 — 9.5	28.8"	Topaz-blue	2^h39^m	+26°46'
π	4.9-8.4-10.2	3.2"	?	2^h48^m	+17°27' (Triple)
		25.2"			
ε	6.0 — 6.4	1.5"	?	2^h58^m	+21°20'

Galaxies

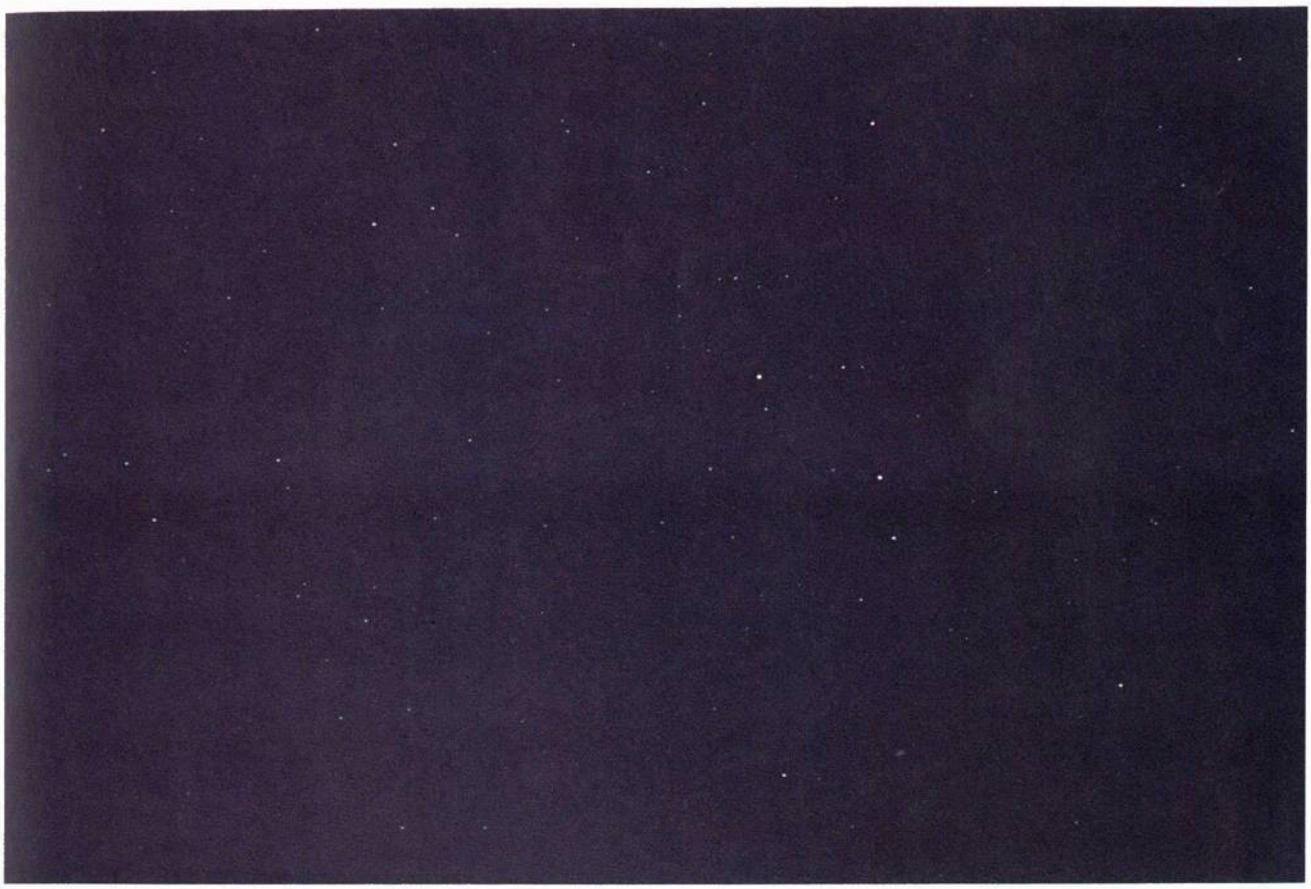
NGC	Messier Object	Magnitude	Size	Type	R.A.	Dec.
772	HI-112	10	5'x3'	Spiral	01^h56^m	19°

EPOCH 1970

Stellar Magnitudes -1 0 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 & fainter

Diffuse Nebula Double Stars Variable Stars

Galaxies Planetary Nebula Open Star Clusters Globular Clusters



Sheratan, at a distance of 52 light-years, are two of the sun's fairly close neighbors. It's interesting to note, however, that if Hamal was as near to us as Arcturus (36 light-years), it would be only four-tenths of a magnitude fainter than that prominent star, and if Sheratan was as near as Altair (17 light-years), it would be six-tenths of a magnitude brighter!

Did Mesarthim have a "figure eight" appearance? It should because it's a double star with a separation of 8.2 seconds of arc. Depending on how low a magnification you used, this double may have appeared as a "single" elongated star or as two stars in contact with each other. Under slightly higher magnification, it is easily resolved. In **The Telescope Handbook and Star Atlas**, Neale Howard lists the magnitudes of the components as identical, while **Norton's Star Atlas** lists them as differing by two-tenths. Could you notice any difference?

As you swept north, slightly east of Beta, you surely must have paused as fifth magnitude Lambda and sixth magnitude 7 Arietis came into view less than 1/2 degree apart. Lambda is another double star, with a seventh magnitude companion at a separation of 37 seconds of arc. Here it was probably the colors, white (or yellow?) and blue, which caught your eye. And as you swept south along this same line of right ascension, did you spot HI-112 out of the corner of your eye? HI-112 is a small, tenth magnitude galaxy lying 1-1/2 degrees east, and 1/2 degree south of Gamma Arietis. It could easily be missed in a six inch or smaller telescope.

Another object in this area that you may have missed is 1 Arietis, two degrees northwest of Beta. A close double with a separation of only 2.8 seconds of arc, it would not be split under low magnification. It is, in fact, a test for a two inch telescope. In a six inch scope at 150x, however, this pair is easily seen, and colors of gold and blue make it a very beautiful sight.

If you were patient and ventured eastward away from the well-known triangle into a region devoid of prominent stars and familiar stellar patterns, you were probably rewarded with more wide double stars such as 30 and 33 Arietis. Or, if you used a moderate sized telescope, perhaps you discovered some of the fainter galaxies in the area. It is certain, however, that you found many objects that have not been described or listed here. Such is the great advantage of sweeping unguided across the skies - to find what is there, unburdened with the knowledge of what is supposed to be.

NOVEMBER

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet.

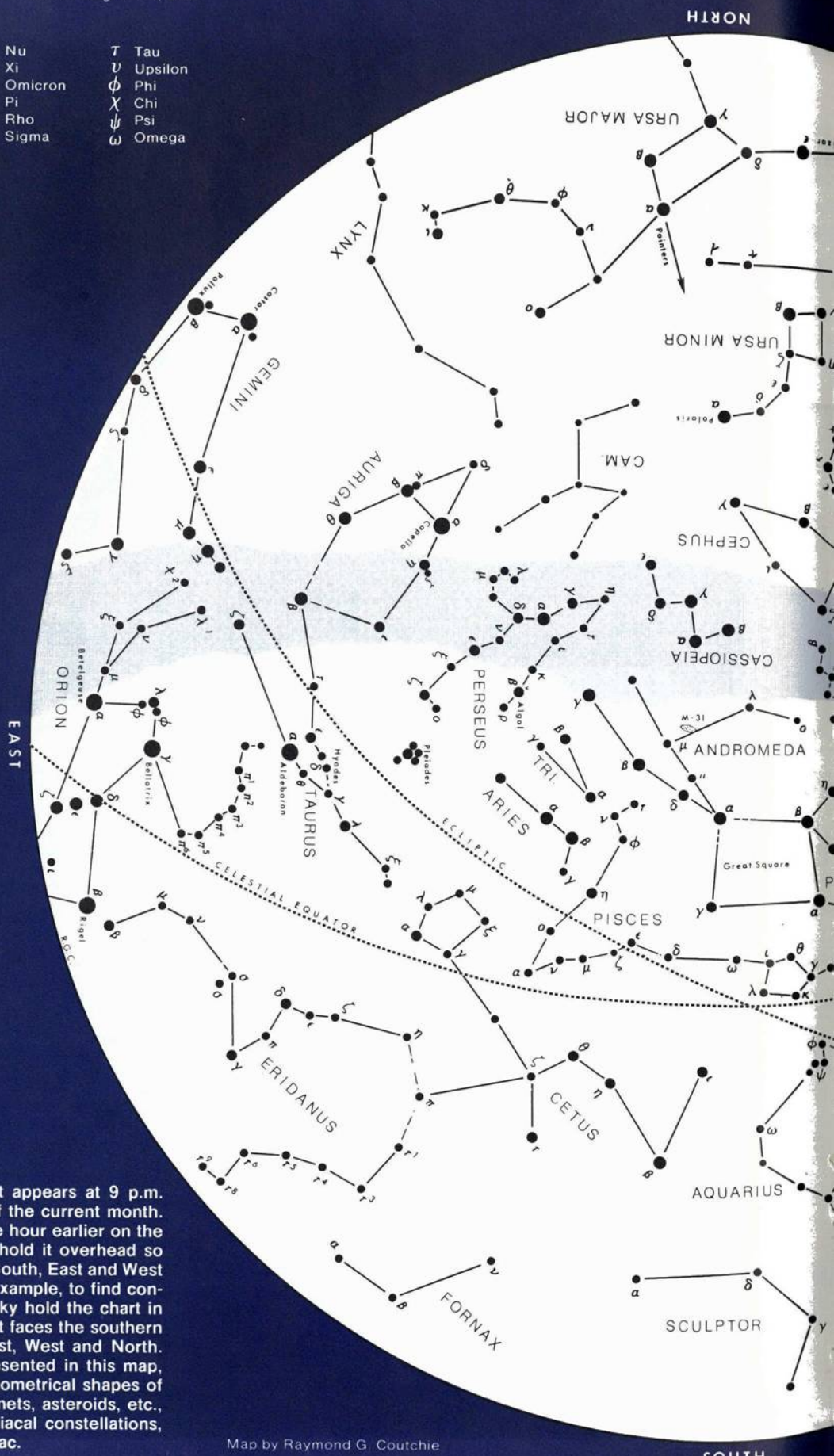
α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	o	Omicron	ϕ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ϵ	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

MAGNITUDES

- Zero
- First
- Second
- Third
- Fourth
- Fifth

OBJECTS

- Open Clusters
- Globular Clusters
- Diffuse Nebulae
- Galaxies
- Double Stars
- Variable Stars



Map by Raymond G. Coutchie

Star Dome approximates the sky as it appears at 9 p.m. Local Standard Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the contellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

STAR DOME

Map Centered on 43° North Latitude

by

John G. Harmon

Many stories exist for all the constellations mentioned by Aratus in his **Phaenomena** (c. 270 B.C.), a poetic description of the sky. In some instances, one myth may involve more than just one or two constellations. A good example of this is the story about Princess Andromeda.

Andromeda was the daughter of Cepheus and Cassiopeia, the legendary king and queen of Ethiopia. Cassiopeia was said to have been very beautiful. Her charms were extolled by many, not the least of which was Cassiopeia herself, for her beauty was matched only by her vanity. Her favorite pastime was to sit by the hour admiring herself in a mirror. Cassiopeia finally claimed that she was even more beautiful than the Sea Nymphs.

The Nymphs, of course, were greatly offended by this boast and complained to Neptune, the god of the sea. As a punishment for her vanity, Neptune sent a sea monster, Cetus, to destroy the kingdom of Cassiopeia and Cepheus.

Cepheus prayed to the gods to end the destruction, and was told that the only way to stop Cetus was to sacrifice his daughter Andromeda to the sea monster. Reluctantly, he ordered Andromeda to be chained to rocks by the sea. She was about to be devoured by Cetus when she was miraculously rescued by Perseus, one of Jupiter's sons, who was on his way home after doing battle with the Medusa.

How was Perseus able to accomplish this heroic feat?

The Medusa, like Cassiopeia, had dared to compare her beauty to that of the gods. As punishment she was changed into a Gorgon, a hideous creature with snakes for hair. This metamorphosed beast was so terrifying in appearance that anyone who looked at her was changed to stone. Perseus had been sent by King Polydectes of Seriphus to destroy the Medusa. To accomplish this task, Perseus was aided by two of the gods - Minerva, who lent him her highly polished, mirror-like shield, and Mercury, who lent him his winged sandals.

With the aid of the sandals, Perseus flew off in search of the Medusa. He finally found her

asleep in a cavern filled with the stone figures of those who had looked upon her. In order to avoid this same fate, Perseus looked instead at her reflection in Minerva's shield. He severed her head with his sword and placed it in a bag where it could do no harm.

Several drops of the Gorgon's blood, however, fell into the sea. From this blood sprang the flying horse, Pegasus. It was while flying back home on Pegasus that Perseus spotted Andromeda and the sea monster.

Perseus took the Medusa's head out of his bag and with it turned Cetus to stone. As a reward, Perseus was given Andromeda as his bride, and although there are several versions of the story, it appears that they lived happily ever after. It is an interesting sidelight that no less an authority than Saint Jerome claims to have seen the petrified bones of the sea monster while at Tyre.

All the major characters in this story are represented by a closely knit group of constellations which extend from near the North Celestial Pole to the southern horizon. Two of these constellations, Cassiopeia and Cepheus, are circumpolar.

While Cassiopeia looks like a letter "M" or "W" in the sky, it actually outlines the throne upon which the queen is sitting. This throne turns upside down during part of its annual circuit around the northern sky to teach Cassiopeia a lesson in humility.

Of Cassiopeia's four brightest stars, three have names which describe their location in the constellation. Alpha Cassiopeiae is called Schedar, from the Arabic Al Sadr, which means the breast. Delta is Ruchbah or the knee, and Theta is Marfak or the elbow. Beta, however, bears the name Caph, which comes from an early Arabic name for the constellation which was Kaff al Hadib or "the hand stained with henna". It was about five degrees from this star that Tycho saw his famous nova of 1572.

Cepheus, a rather inconspicuous group of stars, lies between Cassiopeia and the pole. Despite its dimness, however, it was seen as a separate constellation by many cultures. In China, for example, it was the "Inner Throne of the Five Emperors". Alderamin, Alpha Cephi, a star which marks the right arm of the king, will be our pole star in the year 7500 A.D.

The stars of the constellation Andromeda are almost directly overhead this month. Like Cassiopeia and Cepheus, Andromeda is a very old constellation and was seen as a chained woman by most ancient cultures. In spite of this fact, its brightest star, Alpha, is called Alpheratz or the horse's navel. The name is derived from the fact that it is shared with the constellation Pegasus. Alpheratz is almost exactly at zero hours right ascension (the position of the sun on the vernal equinox), and a line drawn from it through Gamma Pegasi and Beta Cassiopeiae marks the Equinoctial Colure, the prime meridian of the heavens. Beta and Gamma Andromedae have names as well. Beta's is Mirach, the girdle or waist cloth, and Gamma is Alamac from the Arabic Al Anak al Ard, which is a small predatory animal similar to a badger.

The constellation also contains the Great Nebula or M-31, a spiral galaxy more than two million light-years distant and yet visible to the naked eye. This hazy patch was known as far back as the eighth century A.D. It was claimed to have first been examined telescopically by Marius (mayor of Gunzenhausen) on December 15, 1612. He described it as resembling "the diluted light from the flame of a candle seen through horn".

Just east of Andromeda is Perseus. He is pictured as carrying the head of the Medusa which is marked by the star Beta Persei or Algol. This name is derived from the Arabic Ras al Ghul, or demon, as is our modern word ghoul. This star has always connoted evil. The Hebrews saw it as Rosh ha Satan or Satan's head, and the Chinese as Tseih She, the piled-up corpses. This evil connotation is explained by the fact that Algol blinks. It is an eclipsing variable star that dims by one magnitude every 2 days, 20 hours and 48 minutes as a fainter companion passes in front of it.

On the other side of Andromeda is Pegasus; its brightest stars bear names which describe a part of the horse. For example, Alpha Pegasi is Markab or the saddle, and as we have already seen, Delta (Alpha Andromedae) is Alpheratz or the navel. The four brightest stars in Pegasus form an asterism known as the Great Square.

Farthest south of the Andromeda group is Cetus, the sea monster. It is said by some to be a whale, but most pictures show it to have a dog-like head with tusks and with forelegs extending into the river Eridanus. As with Pegasus its star names describe their positions. Alpha Ceti is Menkar or the nose and Beta is Deneb Kaitos or the tail of the whale. Omicron Ceti is a dimmer star which bears the name Mira, the wonderful one. Mira is a long period variable star which changes in brightness over a period of 332 days. It reached its last maximum on May 1st of this year when it was third magnitude, although at times it can be as bright as Polaris. This month it is near minimum brightness and can only be seen in a telescope.

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NASA Photograph

It's Simple to Photograph Constellations

Astrophotography is a highly precise, technical science requiring sophisticated equipment, difficult techniques and expert know-how. This may be true if you're a professional astronomer conducting photographic research at a lonely mountaintop observatory.

But it's not true if **you** want to photograph constellations. All you need is a 35mm camera, a camera tripod, cable shutter release and fast film.

In 10 to 25 seconds using a fast lens and film, and with special film processing techniques, you can take beautiful, unguided photographs of the constellations that look as though they were made with a sophisticated astro-camera, equatorial mount and clock drive. Most 35mm cameras and 2-1/4 reflex cameras will suit your needs very well. These are generally equipped with 50 to 80mm focal length lenses in apertures between 20 and 40mm.

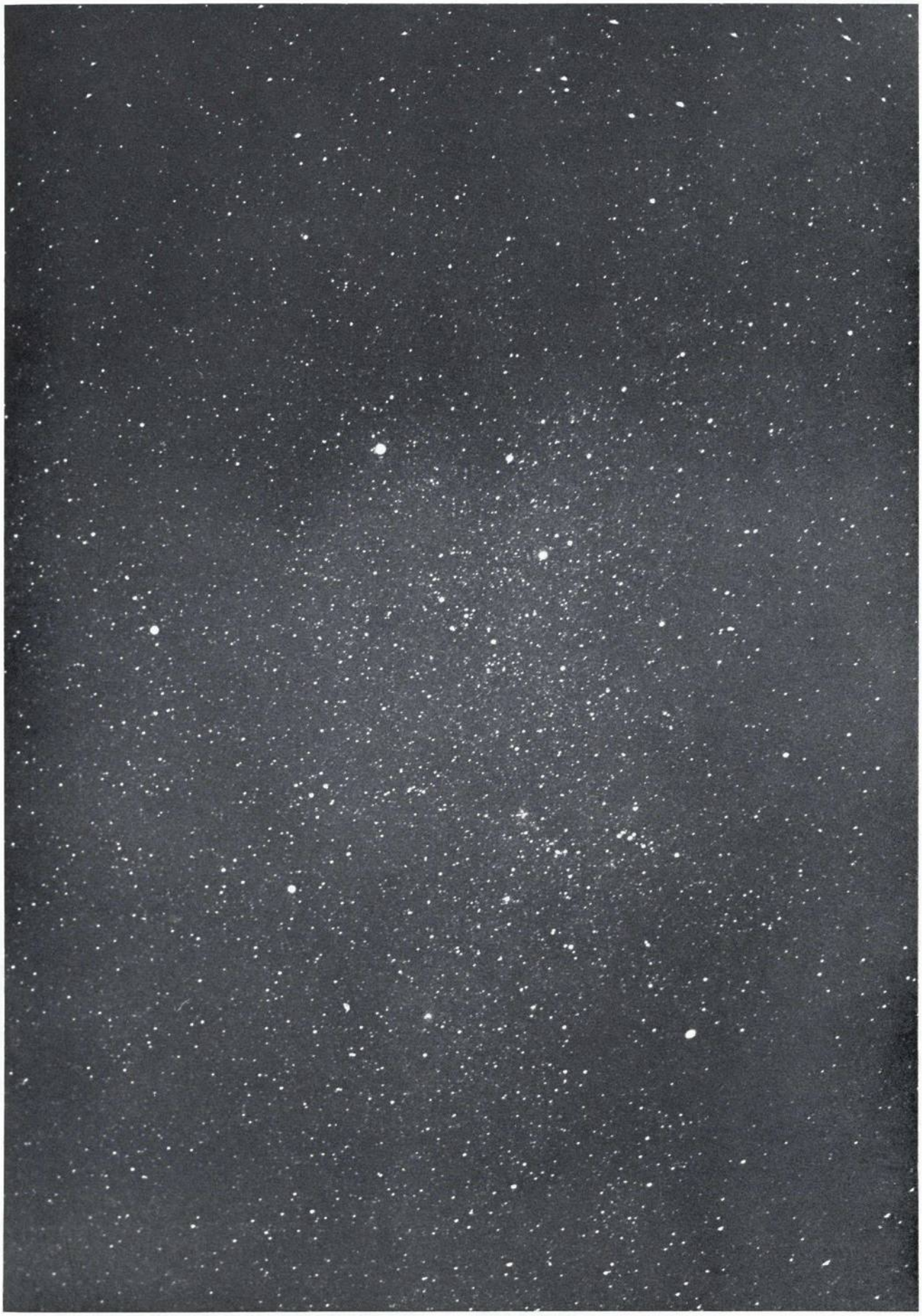
The really important point here is that the camera lens should have as large an aperture as possible and be very fast — between f/1.4 and f/3.5. This will allow you to photograph the faintest stars possible during short exposures.

The Camera

Most constellations cover a large area of the sky. Pisces and Virgo are excellent examples. While a 35mm camera easily photographs all of Cassiopeia, the same camera only records a part of Pisces. (See Pisces photograph on page 45 of the October issue of ASTRONOMY.) For big constellations, a camera with large film format is necessary — such as a 2-1/4 reflex or 4 x 5 view camera. To determine how many degrees of sky can be photographed per centimeter of film (2.54cm per inch), divide 57.3 (about one radian) by the focal length of the camera lens. This is the lens' "field scale".

For example, a typical single lens reflex, 35mm camera, the Minolta SRT-101, is supplied with a lens whose focal length is 55mm or 5.5cm. By dividing 57.3 by the 5.5cm camera lens focal length, we find that the Minolta lens provides a field scale of about 10.4 degrees per centimeter of film. The opening at the back of the camera where the film is exposed — the "film frame" — measures 2.4 x 3.6cm for most 35mm cameras. If you multiply the film frame dimensions by the lens field scale — presto! — you know how much of the sky you can photograph with your 35mm camera. In the example above, the Minolta SRT-

Auriga was photographed with a 35mm Minolta SRT 101 on Kodak Tri-X film. The exposure with the camera's Rokkor f/1.7 lens used wide open was 15 seconds. The Rokkor lens has a focal length of 55mm and a 32mm aperture.



Cassiopeia was photographed with a 35mm Minolta SRT 101 camera on GAF 500 film. The exposure with the Rokkor f/1.7 lens used wide open was 20 seconds. Because this constellation is closer to the celestial pole than Orion, exposure may be as long as 25 seconds before trailing becomes evident.

101 covers about 24 x 37 degrees of the sky.

(For more information about astrophotographic applications of the Minolta SRT-101, write Mr. Robert Norwick, E.T. Howard Co., 850 3rd Ave., Dept. 11A, New York, N.Y. 10022.)

Regardless of the camera lens focal length or the film frame dimensions, by using this formula you will always be able to determine sky coverage. Just remember to consistently divide and multiply the same units of measurement such as inches, millimeters or centimeters.

The Tripod

Since our exposures will be short there is no need for a sophisticated equatorial mount and clock drive. A simple, sturdy camera tripod on which to mount your camera is all you need.

Film & Processing

At the very heart of constellation photography is fast black and white and color film. In black and white the two most easily available films are Eastman Kodak Tri-X and Royal-X Pan. Tri-X at ASA 400 is especially excellent when used with fast 35mm cameras (up to about f/2.8). It may also be used to advantage with 2-1/4 reflex cameras which use 120 or 620 size film if the camera lens is not slower than f/2.8. For slow lens, 2-1/4 reflexes, such as the f/3.5 Rolleiflex, Royal-X Pan at ASA 1250 is the better choice because it is a much faster film.

While Royal-X Pan is not available for 35mm cameras, Kodak 2475 might be tried out experimentally. We say experimentally because 2475 is extremely grainy, producing poor quality enlargements. GAF Super Hypan at ASA 500 is another film with which to experiment. Though the film is basically faster than Tri-X, reciprocity failure is so great that a 13 second exposure does not record stars at the same dimness as does Tri-X. In addition, Super Hypan does not force process as well as the Kodak alternative.

For color slides of constellations use either Kodak High-Speed Ektachrome or GAF 500 in 35mm sizes. Many users of GAF 500 say that star colors are more evident with this film. However, the sky background may have a greenish cast. High-Speed Ektachrome at ASA 160 has less color, but seems to record fainter stars better than GAF 500. Also, the sky background is more pleasingly neutral. If High-Speed Ekta-

chrome is processed commercially, for best results request the special processing envelope, ESP-1. This effectively increases the film speed to ASA 400, and allows the most efficient use of its qualities.

Tri-X and Royal-X Pan film may be developed commercially if you are able to find a lab that custom-processes specific types of film. For best results, however, these films should be home-processed at least to the negative stage. In this way you will be able to make the film do what you want it to — you will be able to record fainter stars and exercise complete quality control.

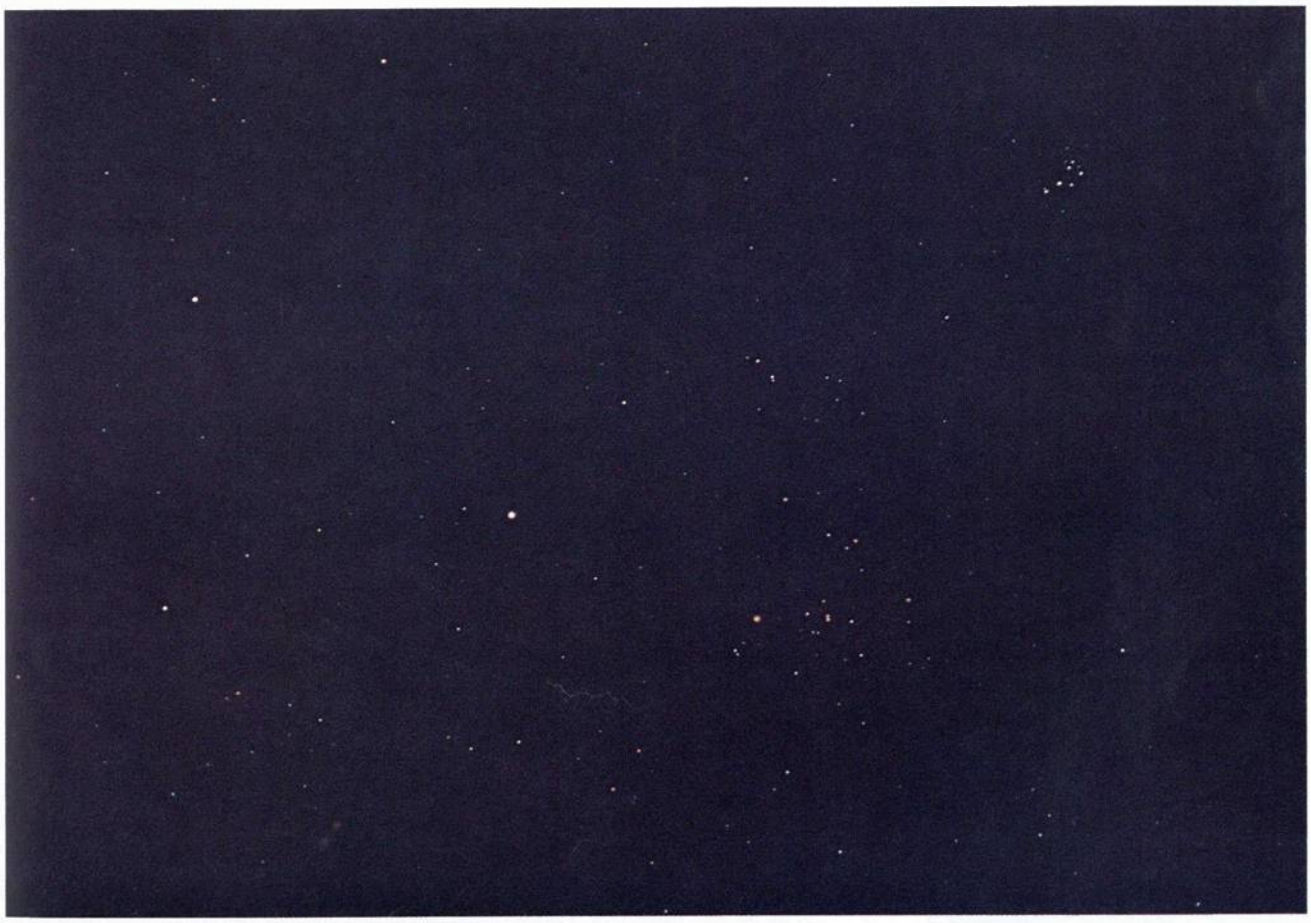
The speeds of Tri-X (ASA 400) and Royal-X Pan (ASA 1250) may be doubled or quadrupled by processing them in Acufine. The key is to double the recommended developing time and use constant, gentle agitation. The effect is a speed increase to about ASA 2400 for Tri-X and ASA 6000 for Royal-X Pan.

(For more information about Acufine developer, write Stephen Amelianovich, manager, Acufine, Inc., 439 E. Illinois St., Dept. 11-A, Chicago, Ill. 60611.)

By using this processing technique you can record a great number of stars during short exposures. As a matter of fact, you will be able to record stars much fainter than can be seen with the unaided eye. In spite of this, there is one major drawback. Fast film is inherently very grainy. Force-developing the film — necessary to record as many dim stars as possible — results in even grainier negatives. When you couple this with small film size (except for 4 x 5 sheet film), you will find that big enlargements of the negatives are difficult to make without excessive grain. For the most pleasing prints, enlargements should not be greater than 8 x 10 inches.

Exposure

The length of exposure is what differentiates simple constellation photography from star trail



Taurus was captured on GAF 500 film during this 15 second exposure. The Minolta SRT 101 Rokkor lens was used wide open at f/1.7. The brilliant starlike object at the constellation's center is the planet Saturn.

The circumpolar constellation Ursa Major was photographed with a 2-1/4 Rolleiflex camera mounted on a simple camera tripod. The exposure was 16 seconds on Kodak Royal-X Pan film at f/3.5 (wide open) with a Zeiss Jena lens.

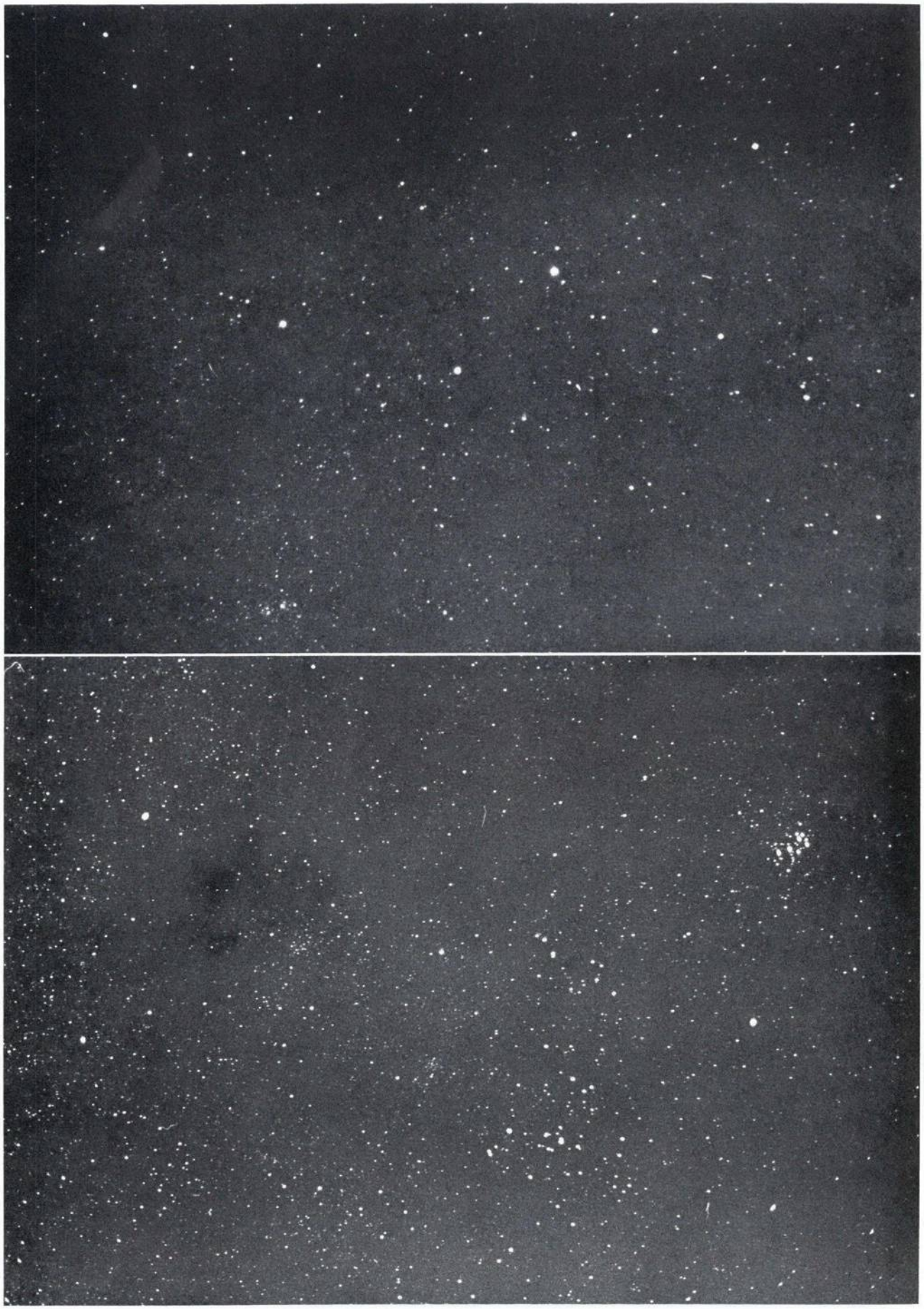
and astrophotography. In star trail photography exposures are long and unguided in order to let star images "move" across the film causing streaks. (See photograph on page 41 .) Astrophotography uses long exposures but attempts to eliminate all trails. Simple constellation photography — actually an outgrowth of star trail photography — seeks to severly truncate star trails by recording only their beginning. The effect is a no-trail appearance as in astrophotography.

Exposure is dependent on two factors: the lens must be fast and have a short focal length, and high speed film must be used. These two factors are dependent on a third — apparent speed of star movement.

When we look at the sky from Earth it's like looking out from the inside of a sphere. This sphere is evenly divided by a line which corresponds to the celestial equator. At right angles to the celestial equator — running directly through Earth's axis — is an imaginary shaft corresponding to the celestial poles. This sphere remains stationary against the star background, but as the earth rotates, it, along with the stars, seems to move. If we drew an imaginary "X" on the celestial equator, we would find that it has a great deal farther to travel in order to complete one circuit of the sky than an "X" placed nearer to the celestial pole. The "X" at the celestial equator would have to travel more "swiftly" to complete one circuit than an "X" at the pole.

Relating this to constellation photography, exposures for stars at the celestial equator must

Simple constellation photography is an outgrowth of star trail photography. The photograph at right is a 20 minute exposure of the Milky Way in Cygnus on High Speed Ektachrome commercially processed to ASA 400. Similar results may be obtained by mounting a camera on a camera tripod and exposing the film for 10 to 20 minutes. In order to show the constellations as they appear in the sky, 10 to 20 second exposures are necessary. Such short exposures severely truncate star trails to produce a "guided" appearance.



This 14 second exposure of Gemini was made with a Minolta SRT 101 on Tri-X film. Notice that the f/1.7 Rokkor lens recorded many more stars during this short exposure than can be seen with the naked eye.

be shorter than at the celestial poles in order to keep the more swiftly moving stars from trailing on the film. Since star movement slows as you move toward the pole, exposure length may be gradually increased. This means you will be able to record dimmer stars at the pole than at the celestial equator.

With the Minolta SRT-101, the best exposure for equatorial constellations (such as Orion) is 13 seconds. In this length of time star movement is so slight that trailing cannot be noticed. With constellations nearer to the celestial pole (such as Cassiopeia), exposures may be as great as 20 seconds without trailing.

Cassiopeia (left above) was photographed with a 2-1/4 Rolleiflex camera. The exposure was 20 seconds on Royal-X Pan film at f/3.5 with a Zeiss Jena lens. This lens has a focal length of 75mm (about three inches) and a 21mm aperture. Taurus (left below) was captured with a Minolta SRT 101 on Tri-X film. Exposure at f/1.7 was 14 seconds.

How To Do It

Armed with all this information you are now ready to do battle with the stars. Simply focus the camera on infinity, open the lens diaphragm to its lowest f/number, and set the shutter on "B" for bulb exposure. Attach a cable release with locking device to the shutter, hold a black card in front of the lens, open the shutter and wait till the camera stops shaking. Next, while the shutter is open, remove the black card and count off your exposure seconds. Terminate the exposure by holding the card over the lens and then release the locking device on the cable release. This exposure technique eliminates "jogged" star images due to shutter recoil.

Photographing constellations can be an extremely enjoyable pastime. There is not only the reward of starting a rather unique collection, but it is also an excellent way for the beginner to learn the constellations. In future issues of ASTRONOMY, especially for Constellation Close-Up, we will use color constellation photographs made by our readers. Our payment for their use is $10.00 each.

This shot of the summer constellation Lyra was made with a 35mm Honeywell Pentax camera mounted on a simple camera tripod. Film used during this eight second exposure was GAF 500. A 200mm focal length lens was used wide open at f/3.5.

Sagittarius was captured here with a Minolta SRT 101 35mm camera. The Rokkor lens was used wide open at f/1.7 during this 15 second exposure on High Speed Ektachrome film. The film was commercially processed to ASA 400.

To Catch a Comet

by

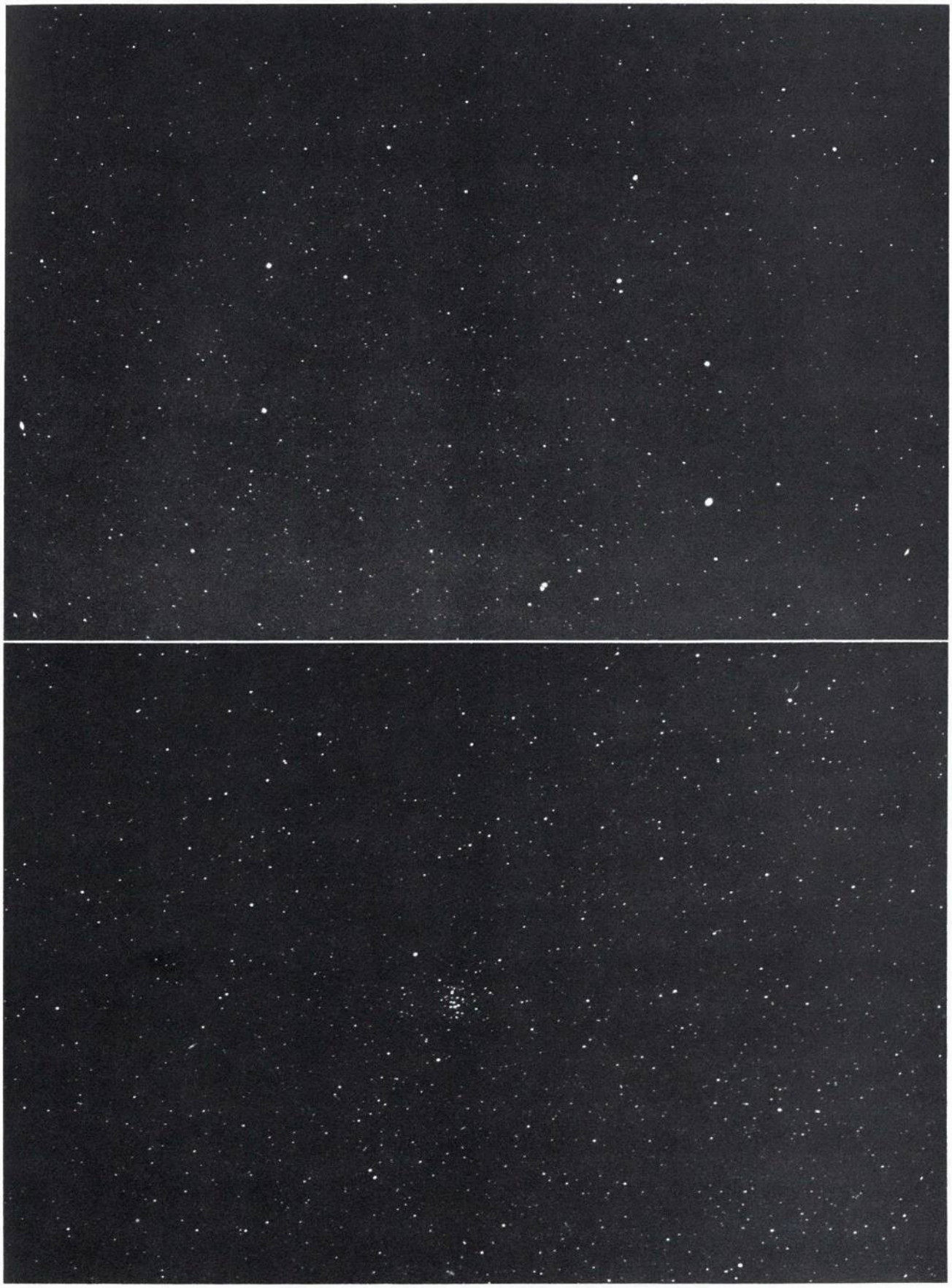
John Sanford

Comet Kohoutek will undoubtedly be remembered as the great comet of 1974, and should present a sky spectacle that anyone may capture on film. The tail of this bright visitor to the solar system may reach 30 degrees in length and reach a brightness more than 100 times that of Venus. Though this great brilliance will last only a few days near sun-passage (perihelion), which occurs December 28, the comet will be a naked eye object from the end of November through the end of January 1974. Because of this it should be an easy sky-target.

Short unguided exposures on fast film, as described in "It's Simple to Photograph Constellations", will allow the photographer to track the comet on its path through the constellations. Longer exposures with a telescope, equatorial mount and clock drive will allow study of tail structure changes and detail in the comet's nucleus. Due to its orbital motion, Comet Kohoutek will move relative to the stars during a time exposure. As a result, advanced photographers may wish to guide their astro-cameras on the comet's head in order to obtain the sharpest, most detailed photos possible.

Since it is fainter than the nucleus, photos emphasizing the comet's tail structure will require high speed film and fast lenses (f/1.4 to f/2.8).

Comet Kohoutek will be brightest when it is near the horizon. For picturesque results the sky shooter might frame the comet with familiar neighborhood landmarks, trees, etc. This not only provides a relevant scale in the picture, but also adds a feeling of reality. For information on viewing Comet Kohoutek, see Gazer's Gazette in the October issue of ASTRONOMY.



The above photographs were made with a Minolta SRT 101 35mm camera on Tri-X film. The camera's Rokkor lens, 55mm focal length and 32mm aperture, was used wide open at f/1.7.

Both Leo (upper) and Cancer were exposed for 14 seconds. Film was processed in Acufine developer for nine minutes at 70 degrees Fahrenheit with constant gentle agitation.

Canis Major, photographed with a 2-1/4 Rolleiflex camera, contains the most brilliant star in the sky — Sirius. This exposure was 14 seconds on Royal-X Pan film with the Zeiss Jena lens wide open at f/3.5. The camera lens has a focal length of 75mm and a small, 21mm aperture. A variety of camera equipment will produce similar or better results. Notice that the open star cluster M-41 is visible in this photo just below Sirius.

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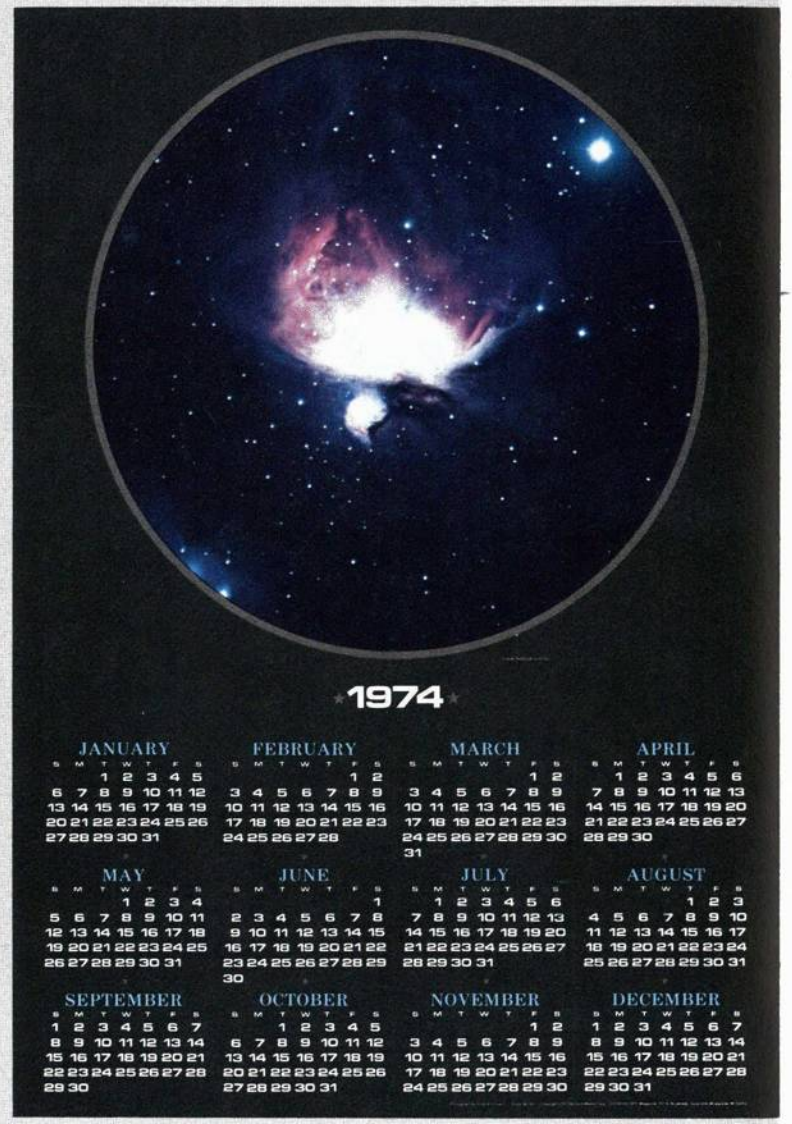

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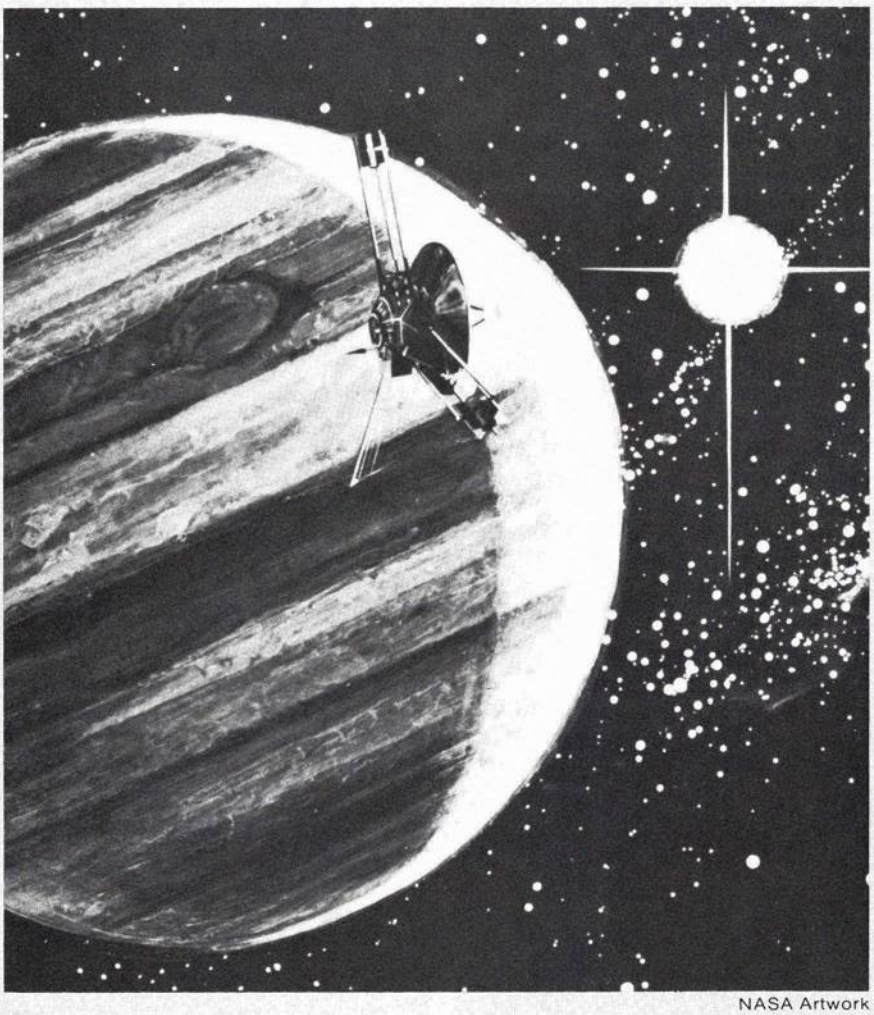
ASTRO-NEWS

Latest News From the World of Astronomy

Pioneer 10 Nears Jupiter

The first manmade spacecraft to reach Jupiter will pass within 90,000 miles of that planet at about 9:30 p.m. EST Monday, December 3, 1973. This is only one Jupiter diameter from the surface of the giant planet. At that time Pioneer 10 and Jupiter will be 512 million miles from Earth. It will take 3/4 of an hour for the spacecraft's signals to reach Earth informing us of its activities in the realm of the solar system's largest planet. However not all of its observations will be made at this minimum distance.

For a week before and after closest approach the spacecraft will send back about two dozen crude television pictures of Jupiter and possibly its moons, as well as about 20 kinds of data on the planet's atmosphere, radiation belts and space environment. Pioneer 10 is targeted to pass behind Io, second of the 12 Jovian moons and innermost of the four large ones. As the spacecraft passes behind the satellite its signals will be deflected in such a way that detection of any significant atmosphere of the satellite will be possible. The experiment will probably confirm the suspicion that Io is virtually without an atmosphere. Jupiter's own atmosphere will be studied in the same way as the spacecraft disappears behind the planet.



NASA Artwork

Pioneer 10 will reach Jupiter on December 3. Here, looking toward the sun, NASA artists conceptualize man's first encounter with the largest planet in the solar system.

The distance of Pioneer 10's closest approach to Jupiter — about 90,000 miles — is large but was chosen for safety reasons. No one knows how dangerous Jupiter's radiation belts are. Some estimates put them at a million times as strong as Earth's. Jupiter is the only planet other than Earth known to have Van Allen Belts, although Earth's are puny when compared to the strength of Jupiter's. These radiation belts could destroy the delicate electronic devices on the spacecraft, turning the flight of Pioneer 10 into a suicide mission. Dust near Jupiter, attracted by the planet's strong gravity, may also be a hazard. But there's only one way to find out.

If Pioneer 10 succeeds, Pioneer 11 — which has already been launched but will not arrive at Jupiter until a year after Pioneer 10 — will be re-targeted in flight to make a closer approach.

As Pioneer 10 flies past Jupiter in a long curving arc, the planet's gravity will nearly double the spacecraft's speed relative to the sun. It will increase from 24,000 to 49,320 miles per hour. Pioneer 10 will then be travelling at too great a velocity for the sun's gravity to hold it. As a result, after the Jupiter encounter, the robot vehicle will become the first manmade

Venus Found Cratered Like Moon and Mars

Huge shallow craters, up to 100 miles across, have been discovered beneath the thick clouds of Venus. A team of astronomers has produced a new map showing a 900 mile wide swatch of Venus, about the size of Alaska, showing a dozen craters in the planet's equatorial region. The surprising discovery was made by using high intensity radar beams piercing the heavy Venusian clouds from the Goldstone Tracking Station on California's Mojave desert.

The cratered map of Venus, resulting from a series of radar beamings on June 20, 1972, was assembled with the aid of computer techniques coupled with the 210 foot and 84 foot radio telescope at Goldstone. These technical improvements allowed probing of the planet to a resolution of about six miles — five times better than the last Venus radar experiment in 1970.

"This area of Venus appears to be as crater-infested as the moon," project director Richard Goldstein said. "Besides the 100 mile crater, others vary from 20 to 60 miles in diameter. None appears to be very deep. The biggest crater is as shallow as a quarter of a mile or so." Other experimenters say the entire area may vary by no more than about 3,300 feet in altitude.

The discovery of craters was unexpected by many astronomers. The thick atmosphere of Venus — 100 times as dense as Earth's — was thought to be turbulent enough some time in the planet's history to erode any craters that might have been caused by impact of asteroids.

The Apollo flights have shown almost all of the lunar craters to be billions of years old. From those Apollo results and other evidence, the solar system's major crater forming period seems to have been between 3.5 and 4.5 billion years ago. The large number of Venus craters and their shallow nature suggests that they were formed during that period. Even if Venus' atmosphere was as dense then as it is now, it could not have prevented the impact of the objects that blasted out 20 to 100 mile wide craters. The question then becomes "why are they still intact and not eroded?"

At the present time there are virtually no surface winds on Venus according to Dr. Carl Sagan of Cornell University. "The atmosphere is so dense and its mass so great that it maintains a very stable temperature profile," Sagan said in a recent interview. He explained that observations by Soviet spacecraft had shown both the day and night sides of Venus are essentially the same temperature," and there is no reason to expect the polar regions to differ from this mean surface temperature".

Even the long Venus day (117 Earth days) is not long enough to allow significant temperature differences to develop. What the discovery of the craters does suggest is a past history of geologic activity that is less violent than Earth's. Sagan concluded by saying that the nature of the forces that shaped and eroded the surface of Venus "is still a very tricky question".

Pioneer 10 (Continued)

object to leave the solar system. It will cross the orbit of Saturn in 1975 and pass the orbit of Uranus in late 1979. After that there is little hope of receiving transmissions from it. Even after crossing Uranus' orbit the spacecraft may continue faithfully observing and transmitting but its signals would be so faint that even our best receivers could not pick them up.

By the time Pioneer 10 leaves the solar system, the sun's gravity will have slowed it to a speed of 25,500 miles per hour. After travelling at that speed for about 80,000 years, the spacecraft will reach the distance of the nearest star. It will not, however, be going in the direction of that star so nothing will mark the event. The first star it will pass (within a few trillion miles) will be Aldebaran in about 1.7 million years. There is no significant chance that it will ever hit a star as the spaces between them are too vast.

Pioneer 10 will wander among the stars presumably forever, but will not leave the Milky Way galaxy. Like the stars themselves, it will orbit the center of the galaxy completing one revolution about every 250 million years. If by some dramatic chance, Pioneer 10 is someday found by an extraterrestrial civilization, those beings will find a small plaque purposely set in a location protected from the erosion of interstellar dust. The plaque tells in pictures and symbols, hoped to be universal, who we are, where we are in the galaxy and why Pioneer was launched.

Spacecraft Sale to Soviets Blocked

Among the thousands of flawless pieces of hardware of the Apollo program were the spacesuits worn during the astronauts' excursions on the lunar surface. The bulkiness of the suits hindered the explorers relatively little considering the hostile environment they were working in. As the missions progressed from the first landing in 1969 through to Apollo 17 in December 1972, the suits improved allowing increased mobility for the exploring earthmen.

Much of the push to achieve lunar landing before the end of the last decade was aimed at beating the Soviets in achieving a similar goal. But apparently the Soviets gave up their moon landing attempt in 1968 because of continued failure of their equivalent to the Saturn 5 rocket.

However there does seem to be concerted interest in eventually having Soviet cosmonauts walk on the moon because earlier this year a contingent of Soviet engineers and scientists requested to purchase 10 of the Apollo lunar spacesuits. After several months of debate among various United States government officials, the Soviets were told that the suits were not available. Apparently the export of such advanced technology to the Soviet Union could not be approved at higher levels of the government.

Final Skylab Plans Comet Kohoutek Viewing

Excitement is continuing to mount as Comet Kohoutek (pronounced Kă-hō'-tek, meaning "little rooster" in Czechoslovakian) nears its December 28 rendezvous with the sun. The final Skylab crew, due to be launched sometime this month, will be taking a special "comet" camera with them. It is an ultraviolet camera, similar to the one used on the Apollo 16 mission, with which the astronauts hope to capture pictures of Kohoutek and especially the hydrogen cloud that is expected to surround it. Estimated to be at least six million miles in diameter — about seven times the diameter of the sun — the cloud is a spectacular rarified envelope invisible from Earth.

Hydrogen clouds surrounding comets are a recent discovery. In 1969 and 1970 the orbiting astronomical abservatory (OAO 2) observed them enveloping Comet Tago-Sato Kosaka and Comet Bennett.

In addition to the ultraviolet camera they will be taking with them, the Skylab crew has available a battery of high powered devices with which to survey the comet. These include an instrument normally used to photograph the corona of the sun (in visible wavelengths of light) and several ultraviolet cameras and spectrometers that were normally intended to photograph the sun and stars. The use of some of these intruments will require rolling the Skylab spacecraft 90 percent — a procedure that can't be done more than twice a day during the prime observing period due to limitations in the spacecraft's maneuvering propellent.

Besides providing new information on the structure and size of the comet itself, the Skylab experimenters expect they will gain new data on the solar wind. So far the solar wind has not been measured within forty million miles of the sun, but Kohoutek will be 13 million miles from the sun at its closest approach. Observations at that time will indicate the speed and direction of the solar wind. Comets are directly affected by this outflow of protons from the sun since their gaseous tails are a direct result of the pressure of the solar wind upon them.

Dr. Stephen T. Maran, an astronomer at the Goddard Space Flight Center, manager of 'Operation Kohoutek' said, "Skylab, with its big array of cameras and telescopes, has more capability than all our other satellites put together." He emphasized the fact that Skylab would be able to make detailed and extended observations of this rare celestial phenomena.

The final Skylab crew, consisting of Gerald P. Carr, Edward G. Gibson and William R. Pogue, will be launched on or about November 10 according to present plans. But such a launch with a 56 day mission would mean the astronauts would be coming down in early January, just after the comet passed its closest approach to the sun, and a time when it should be going through its most active stage. Mission planners are hoping to either delay the launch by ten days or to extend the mission to 70 days to allow the crew to observe the comet's prime period.

Hale Observatory Photograph

Halley's Comet was one of the most spectacular comets of the 20th century. This year, however, Comet Kohoutek is expected to rival Halley's enduring fame and become the Great Comet of the Century.

Other spacecraft involved in the Kohoutek viewing include Mariner 10, which will be on its way to Venus and Mercury. This sophisticated robot craft will have high resolution cameras that will be able to photograph the comet in some detail although not as much as Earth-based observatories. The advantage in observing from Mariner 10 is that it will give us a picture of the comet from a different viewpoint thus allowing scientists to develop a three dimensional image of the comet.

Pioneer 8, in orbit around the sun in a path similar to Earth, will be on the other side of the comet and in position to transmit signals back to Earth through the comet's tail. Analysis of the changes in the radio signals could shed new light on the nature of the tail.

OAO 3, the Copernicus satellite which has a 30 inch telescope, will be able to take detailed spectrograms in ultraviolet light. These should record temperature variations and motions of the hydrogen surrounding the comet's head.

OSO 7 is a satellite developed specifically for observing the sun from Earth orbit and is expected to be able to make observations during the time when the comet is closest to the sun.

Meanwhile on Earth, telescopes from the 200 inch Mt. Palomar on down to the amateur astronomer's binoculars will be trained on Comet Kohoutek. Even radio astronomers are getting into the act. In hopes of determining its diameter and structure, Dr. Richard A. Goldstein of the Jet Propulsion Laboratory will use the 210 foot antenna at Goldstone, California in an attempt to bounce radar signals off the nucleus of the comet.

Have Extraterrestrials Influenced Life on Earth?

Many science fiction authors have suggested that Earth has been visited or will be visited by beings from another world. Usually the aliens are far more advanced than we are and have designs on taking over our planet for some devious, or perhaps to them, inevitable purpose. Eric Von Daniken, in his popular work, **Chariots of the Gods**, suggests that Earth was visted in historic times and that several thousands of years ago our ancestors were influenced in a variety of ways that allowed them to advance more rapidly than otherwise would have been possible. The details of his theory have met with criticism from many quarters, but the basic premise that intelligent and highly advanced beings from other worlds have visited Earth remains an intriguing speculation.

In a recent issue of **Icarus**, the international journal of solar system studies, three speculations on extraterrestrial life offer different twists to this popular idea.

In the first, Dr. Francis Crick, Nobel Prize winning researcher at the Medical Research Council, Cambridge, England and Dr. Leslie E. Orgel, at the Salk Institute in San Diego, suggest that life in all its forms on Earth came from another planet. According to their theory, called "directed panspermia", the basic elements of life — the micro-organisms from which all life on Earth seems to have evolved — were planted here by intelligent beings between three and four billion years ago.

A popular assumption in recent years is that whenever the conditions are such that life can exist and evolve, it will do so. This assumption has never been proven, although it has been extrapolated from biological experiments conducted in the last two decades. Crick and Orgel say that if it has never been proven that the emergence of life is a common occurrence in the universe, then we cannot be sure that life in fact will evolve where conditions are appropriate. So they suggest taking the opposite view and assume that the emergence of life is rare. Therefore any life that has evolved would eventually discover that they were essentially alone in the universe.

In order to preserve the element of life in the universe they may decide to transport micro-organisms to other worlds, plant those micro-organisms and let the course of evolution that took place on their planet, take place on another world. Crick and Orgel say that "some form of missionary zeal" may drive advanced civilizations to seed lifeless planets.

Considering that the Milky Way galaxy is about 13 billion years old, the two theorists say there has been plenty of time for the origin of life on at least a few planets. The subsequent inevitable development of technology on a handful of worlds would make transport between planets a likelihood by now. Assuming these advanced civilizations are very rare — say only a few per galaxy — the two scientists insist their proposal is not as bizarre as it first sounds. They go on to propose that spaceships capable of carrying large samples of a variety of micro-organisms, each having different nutritional requirements, would drop their cargos on various young planets

Pole Cap Panorama

NASA Photograph

This recently released NASA photograph is a blowup of a mosaic showing the northern hemisphere of Mars. The section shown here reveals the wealth of detail Mariner 9 recorded in Mars' north pole cap. Scientists believe the surface layer of the pole cap may be frozen carbon dioxide over a thick mantle of water ice.

of newly evolved solar systems. During the voyage the micro-organisms could be preserved at temperatures approaching absolute zero. This would be a project for a very highly advanced civilization to whom time would not be a disturbing element in the experiment. It would take millions of years to send these suggested robot probes to the various worlds.

Is there any evidence that life did not evolve here on Earth without the assistance or intervention of extra-terrestrials? The two biologists say there may be. They point out that the element molybdenum plays an essential role in many enzymatic reactions in living things. Molybdenum is very rare on Earth — in fact so rare that it is considered a trace element being only 1/5000 of the constituent elements of our planet. An element like nickel has a three percent rating when we weigh the earth and separate it into its various elemental contents, and yet nickel plays virtually no role. The authors go on to say that molybdenum is probably irreplaceable in the life giving processes that take place here on Earth. Why should that element play such a role when it is so exceedingly rare on our planet? They point out that there are molybdenum stars, but they cease to speculate further.

A second argument that they offer is the genetic code which is universal to the earth. There is only one genetic code, yet if life sprang up spontaneously should there be a multitude of genetic codes? However if life sprang from an implanted organism, only one genetic code would be expected.

If it is some day proven that this theory is correct, are the senders or their descendants still alive or have the hazards of four billion years of further evolution been too much for them? Has their star inexorably warmed up and frizzled them or were they able to colonize a different solar system with a short range spaceship? Have they perhaps destroyed themselves either by too much agression or too little? Professors Crick and Orgel conclude by suggesting that perhaps the galaxy is lifeless except for a local village of which we are one member.

In the same issue of **Icarus**, John A. Ball offers the "zoo hypothesis". He too suggests that there are others beyond Earth who are aware of our existence, but he proposes a completely different theory. Ball's suggestion takes the reverse assumption of that of Crick and Orgel. He, like many others, assumes that life, even intelligent life, is fairly common in the universe. If this is true, then there must be many civilizations that are aware of us. And yet Ball says we have absolutely no evidence of their existence. He suggests that a highly advanced civilization could very easily make us aware of their existence. Although the flying saucer buffs would argue otherwise, he says no evidence has been put forward. So he concludes that Earth is essentially a wildlife preserve. His zoo hypothesis requires a noninteraction between them and us just as we would like to have in our wildlife preserves here on Earth — a completely self-contained environment that is overseen from elsewhere but not interfered with. Ball believes this idea is pessimistic and psychologically unpleasant, admitting it would be more pleasant to believe they would want to talk with us. However the history of science contains numerous examples of psychologically unpleasant hypotheses that turned out to be correct.

Dr. Carl Sagan of Cornell University offers a third speculation along these same lines. He suggests that civilizations, far in advance of our own, would only be interested in communicating with us if they were conducting research into antique communication modes. He feels that otherwise they would have little interest in a civilization far inferior to their own. Sagan believes only those civilizations that are within a thousand years of us (on an evolutionary scale) would be the ones that would be anxious to communicate with us, and that these would have the weakest transmitters and therefore be the most difficult ones to detect.

Those civilizations more than a thousand years in advance of us would be, Sagan feels, less likely to be searching for us or attempting to communicate with us. It may be that they are as interested in us as we are interested in the psychological makeup of chimpanzees.

Decade of Quandry Greets Quasar 10th Anniversary

This year marks the 10th anniversary of the discovery of the nature of 3C 273, the first quasar. During this interval hundreds of these enigmatic objects have been catalogued and billions are postulated.

The nature of quasars probably ranks first on the list of cosmic puzzles. They are believed to be the brightest and most distant objects in the universe. Their huge redshifts (see "Cosmic Dimensions" in this issue) imply that they are billions of light-years away — many of them farther than the most distant galaxies.

Assuming the redshift measurements are a true indication of a quasar's distance (most, but not all, astronomers support this idea) then two recently observed quasars are incredibly far away. Quasar OH 471, receding at 89 percent of the velocity of light according to two University of Arizona astronomers, is about 10 billion light-years distant.

Two months after that discovery E.M. Burbidge of the Royal Greenwich Observatory and E.J. Wampler of Lick Observatory announced measurements for quasar OQ 172. Its redshift showed a recession of 91 percent of light's velocity — 170,000 miles per second. That puts it about 11 billion light-years from the Milky Way galaxy.

The new quasars were found from data supplied by British radio astronomers who predict the discovery of even more distant quasars in the near future.

One nagging problem still remains. What energy source is responsible for the quasars? Galaxies at these remote distances would be far too faint to be detected. What type of object can produce 100 times the energy output of an entire galaxy, yet by measurement be shown to be far smaller than a galaxy? For the present, no one can say.

Pioneer 10 Finds Asteroid Belt Less Dense Than Thought

Pioneer 10 was launched on March 2, 1972 and left Earth at 32,000 miles per hour — more rapidly than any spacecraft before it. It covered the distance to the moon in 11 hours. On May 25 it crossed the orbit of Mars, and in early July 1972 entered the asteroid belt. As the first manmade object to traverse the asteroid belt, the study of this zone of the solar system became a significant part of Pioneer 10's mission.

The densest parts of the asteroid belt are about midway between Mars and Jupiter. Only 2,000 asteroids are catalogued, most of them having a diameter of more than one mile. Smaller ones are generally not visible in Earth telescopes and their number has been largely open to speculation.

So it was part of Pioneer 10's duties to attempt to determine the quantity of small particles in the previously unexplored asteroid belt. None of the 2,000 larger asteroids came closer than two million miles from Pioneer 10. It was thought that some of the smaller unknown particles might damage the craft as it made its way through the region.

As it turned out, Pioneer 10 not only survived its passage of the asteroid belt, but it made the startling discovery that the number of small dust particles from 1/10 to 1/100 of a millimeter in size is no greater in the asteroid belt than in the vicinity of Earth. The number of very small particles, approximately 1/1000 of a millimeter in size, is actually less in the belt than near Earth. Particles of sand grain size and bigger show a slight increase in concentration in the asteroid belt but these are still too rare to pose any danger to spacecraft.

This surprising paucity of matter in the belt is further complicated by recent calculations showing that the observed particles are probably debris from comets (which would also explain why there is about the same amount there as near Earth). Exactly why more material wasn't added by collisions among asteroids remains a puzzle since much more material was predicted to be in the belt than Pioneer actually observed.

Pioneer 10 left the asteroid belt in mid-February 1973. However it was not idle during this period. Its instruments continued to observe the dust, gases and magnetic fields of interplanetary space. In addition, the gases and cosmic rays that enter the solar system from interstellar space and the solar wind were documented. The spacecraft discovered that solar wind — the constant thin outflow of gases from the sun that fills the inner solar system — slows down but somehow manages to heat up as its distance from the sun increases. There is some hope that the spacecraft may eventually pass through the outer boundary of the solar wind thus finally settling the argument over where that boundary is. This will not happen until after it passes Jupiter, and the spacecraft signals may become too weak to be picked up on Earth before the solar wind peters out.

Four Soviet Spacecraft on Way to Mars

As of July of this year the Soviets had launched a total of nine spacecraft toward the planet Mars. But of these nine, only two worked — Mars 2 and Mars 3. Both spacecraft reached Mars in late 1971 and released landing capsules, one of which apparently intentionally crashed on the planet. The other survived a semisoft landing on the Martian surface. This surviving surface vehicle — the first functioning craft ever to land on Mars — began to transmit television pictures of the Martian surface. But its transmissions terminated after only 20 seconds for reasons which are still not clearly understood by either Soviet or United States scientists. Each landing probe had an orbiting section, which is still circling the planet. However, the information returned from the orbiters (in terms of photographs and other data from onboard sensors) is far less than that obtained from U.S. Mars probes.

In an attempt to gain prestige and to add to earthmen's body of knowledge of the red planet the Soviets have launched four new spacecraft in their Mars series. They were all launched in late July or early August of this year and are expected to reach the planet in March 1974.

The Soviets have revealed that Mars 4 and 5 — the first two craft launched this year — have a different purpose from Mars 6 and 7. Western scientists speculate that the first two vehicles will go into orbit around Mars and the second two will attempt soft landings. The prime function of the landers will be to transmit live television pictures from the surface of our neighbor world. However they may release roving vehicles that will trundle across the surface of Mars in an exotic experiment that could greatly increase our knowledge of the red planet. If rovers are used they will not be controlled from Earth as the Lunakhod moon rovers were. The transmission time delay is too great — from 4 to 12 minutes depending on the Earth-Mars distance. Onboard computers will have to be the "brains" for Mars Rovers — a complex but potentially rewarding experiment.

The landing sites for Mars 6 and 7 were selected after examination of Mariner 9 photographs provided by NASA. U.S. and Soviet scientists are planning a meeting later this year that will pin down details as to how the information-sharing on Mars exploration will continue since there will be great eagerness to see any surface photographs successfully transmitted from Mars.

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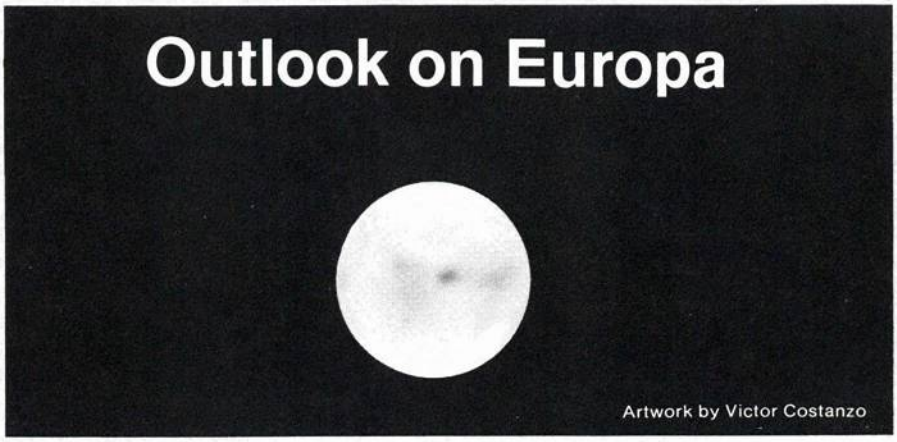
Outlook on Europa



Artwork by Victor Costanzo

In a small telescope the four large satellites of Jupiter appear as tiny points of light strung out in a line on either side of the planet. In eight inch or larger telescopes, observers have reported seeing the actual disks of these miniworlds. With large instruments, in ideal locations, enough detail has been observed to compile maps of the four big moons.

The most detailed of these maps were made in the 1950s using the 24 inch visual refractor at the Pic-du-Midi Observatory in the French Pyrenees. A drawing of Europa as it appears through this telescope in excellent seeing is shown on this page. Almost all Europa drawings show featureless white polar regions. In addition, other investigators have learned that this smallest of the "big four" is also the most reflective, bouncing back about six times as much light as Earth's moon.

Now a University of Hawaii astronomer feels he has confirmed what others suspected — snow on Europa. Dr. Robert E. Murphy observed Io, Jupiter's inner major moon, occult Europa on two occasions. As Europa was cut off from Earth's view, Murphy made photoelectric observations from which he deduced that a polar cap covers at least half of the northern hemisphere of Jupiter's second major moon.

Venus Cloud Waves Detected

The top layer of the thick Venus cloud deck may move up and down in a constant wave motion with each wave over half a mile high. That finding has been reported by a group of scientists headed by Dr. Louise Gray Young following infrared spectrum observations at Table Mountain Observatory in Angeles National Forest, Calif. The astronomical team made its fluctuating cloud bank deduction after observations revealed a 20 percent variation in carbon dioxide absorption exists all over Venus.

"The apparent strength of the carbon dioxide absorptions varied this much over a cycle of four days," the team reported. Their observations were conducted last fall using Table Mountain's 24 inch telescope and spectrograph. Previous observations by other astronomers using ultraviolet rather than infrared detectors had indicated a four day cycle of some sort takes place on Venus.

But what exactly is happening on Venus?

"To produce the observed changes," the investigators said, "the cloud tops must be moving up and down over a half mile over the entire planet. We seem to be observing a fundamental feature of atmospheric dynamics that is not explained by current theories of atmospheric circulation on Venus."

An extremely large amount of energy would be needed to produce this shift in the cloud-top level, the scientists said. They add that "it is difficult to see where it can come from."

Venus rotates once every 117 days and is completely shrouded in clouds. Two hundred miles per hour circulation has been detected in the upper atmosphere and is undoubtedly related to cloud waves, though the relationship is unclear.

Photocomposite Mars Globe Built

A unique photomosaic globe of Mars — the first detailed map of any planet fashioned from spacecraft photographs — has been completed at the California Institute of Technology's Jet Propulsion Laboratory. It is the first of three large photo-spheres of Mars JPL is assembling for the National Aeronautics and Space Administration.

The initial four foot globe involved painstaking reorientation of thousands of photographs of the red planet returned by the Mariner 9 spacecraft. Not even Earth has yet been completely mapped by photographs from spacecraft or satellites, according to Elmer Christensen, scientist in charge of the Mars global mosaic project.

The globe — comprising over 1500 photographs, some no larger than a postage stamp — required seven months to complete. The remainder of the project won't take so long, because the first globe is being photographed in three to five inch segments which will be glued onto the other two spheres. Creating the first Mars globe was an intricate, arduous process. Gluing the black and white photos on an aluminum sphere was just the final step. Before that, Christensen points out, several steps were taken:

The photos returned by Mariner spacecraft were mostly angle shots, which had to be rectified by computer processing to show the Martian surface as it would appear from directly above any given point. The photographs were corrected to an identical scale to prevent errors in the size of features. They were developed with exactly the same degree of contrast to assure accurate shading variations of the surface. Each section had to be oriented precisely in longitude and latitude and matched perfectly to adjacent segments. Finally a scalpel-like blade was used to trim sections to fit perfectly into the global jigsaw puzzle before gluing.

Two of these four foot globes are being fashioned — one for NASA headquarters in Washington, D.C., and the other for NASA's Lewis Research Center, Cleveland, Ohio. A third Mars sphere, six feet in diameter, will be on display in JPL's museum.

SKY ALMANAC

Mercury Transit Highlights Viewing as Parade of Planets Continues

by

Terence Dickinson

Crisp, late autumn air and early darkening skies offer a wealth of viewable objects to the diehard observer this month.

Mercury

A rare transit of Mercury occurs Saturday morning, November 10, 1973. Unfortunately the event may only be viewed by observers in the eastern half of the United States. For more information on this transit, see Gazer's Gazette this month.

Mercury will be visible in the early morning sky as the fleet planet races from its rendezvous with the sun on November 10 to greatest western elongation on the 27th. Greatest western elongation simply means Mercury appears at its maximum distance west of the sun on the 27th. For about five days on either side of that date Mercury can be seen as a zero magnitude "star" above the southeastern horizon just before sunrise.

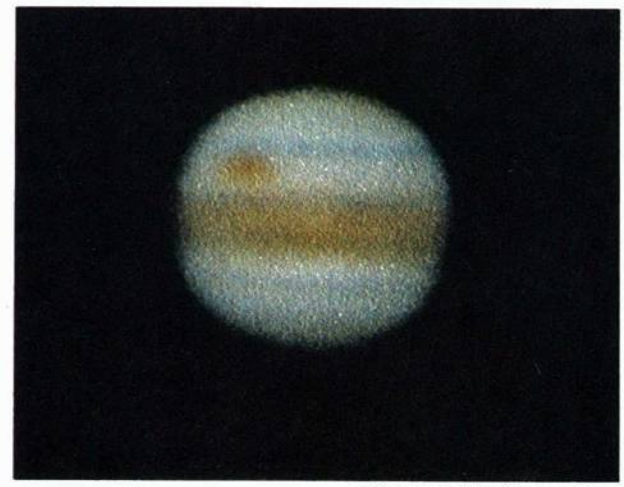
Jupiter

The giant planet is well up in the southwest as the evening sky darkens. It should be the second object on your observing list (a quick look at Venus is first). Although Mars gives Jupiter some competition this month, the great multi-banded world and its attendant moons are, as usual, prime targets for any telescope.

For the first two weeks of November, Mars outshines Jupiter. But by late in the month, at magnitude -1.7, the giant planet again dominates the evening sky. The telescope reveals the planet's oval disk that dwindles from 40 to 36 seconds in equatorial diameter during the month.

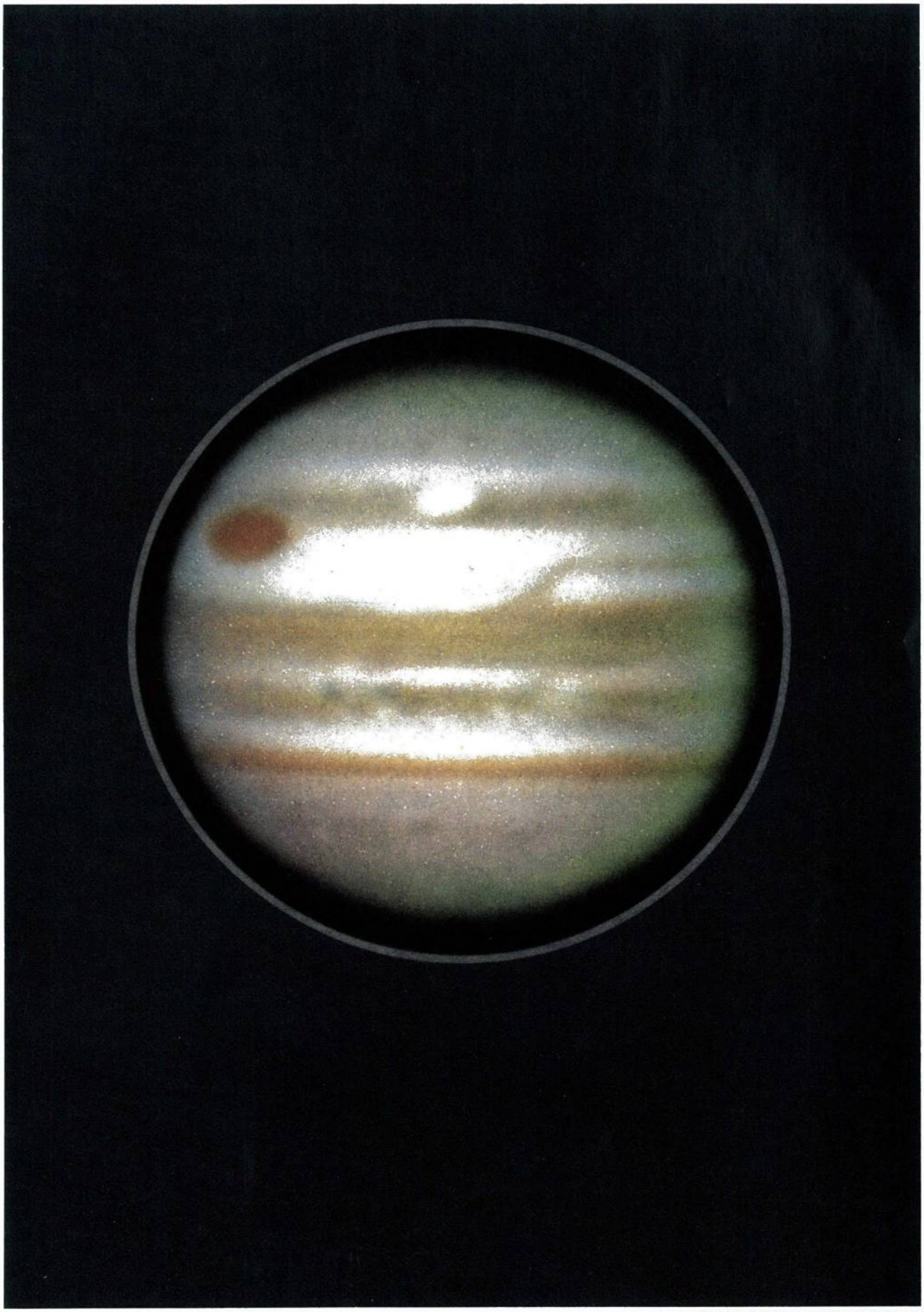
The ever-present dance of the moons continues as shown in our monthly chart. Remember that these positional diagrams are for a normal inverting telescope. Binocular users have to turn the magazine upside down. (The shadows of the moons are the subject of an interesting comment by Thomas C. Bretl in Letters to the Editor.)

As in previous months, some eclipses of one satellite by another are predicted for North American observers. We have received reports of satellite eclipses that were observed in August



Photograph by Steven Reed

Jupiter's brilliance still dominates the evening skies this month. The color photographs here compare what a professional astronomer sees with his telescope (see Lunar & Planetary photograph) and what can be seen with amateur sized telescopes (see the photograph by Steven Reed). Notice that the great red spot is quite evident in both photographs.



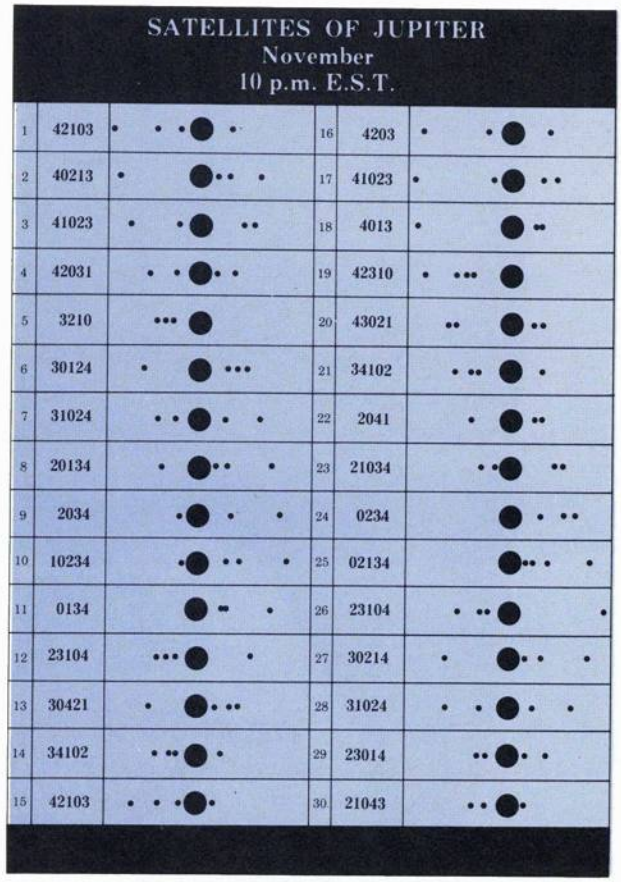
Lunar & Planetary Laboratory Photograph

and September stating that the rapid dimming of the eclipsed moon is a "spectacular" sight. We will have a complete roundup of these reports in a future issue. In the meantime November is the last chance, probably for this decade, to see a nearly total eclipse of a moon of Jupiter.

As the table indicates, there are two partial and two annular eclipses. During the partial events, the eclipsed moon will drop to about half a magnitude from its normal brightness. All times indicated are for mideclipse, so begin watching at least 15 minutes early.

In the annular events a large telescope in the hands of an experienced observer under good seeing conditions (we're not asking for much!) may reveal the outer limb of Io (1) as a faint ring since the central region of that moon will be in Europa's (2) shadow. Smaller telescopes will show a definite, rapid fading of Io to near invisibility. It should be an exciting spectacle even in a small telescope.

The final listing, November 26, is so rare that no one has ever seen it before. Europa will be totally eclipsed while it is in front of Jupiter. The normally, nearly invisible transiting moon will suddenly become dark as Ganymede's (3) shadow falls on it. It will momentarily seem to materialize and, within minutes, rapidly disappear as the shadow moves off Europa. At the same time the shadows of both Ganymede and Europa will begin transiting Jupiter's disk (see table of satellite shadows on Jupiter). A six inch or larger telescope will probably be required for satisfactory observation of this ultrarare series of events which, incidentally, can only be seen from the eastern third of North America.



The positions of Jupiter's four brightest moons change hourly and daily, and make an interesting sight to view even in a small telescope or high powered binoculars. Shown above is the approximate appearance of Jupiter and its satellites as they might look in a small telescope at 10 p.m., EST. First column on the left shows the date. Second column of numbers identifies the moons and their position relative to Jupiter's disk. 1=Io; 2=Europa; 3=Ganymede; 4=Callisto, and 0=Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions.

ECLIPSES AMONG JUPITER'S MOONS

Date	Time (E.S.T.)	Event	Comments
Nov. 4	10:40 p.m.	shadow of 3 falls on 1	partial (70%)
11	8:30 p.m.	shadow of 2 falls on 1	annular
18	10:45 p.m.	shadow of 2 falls on 1	annular
19	7:55 p.m.	shadow of 3 falls on 1	partial (70%)
26	6:15 p.m.	shadow of 3 falls on 2	

1=Io
2=Europa
3=Ganymede
4=Gallisto

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit begins (E.S.T.)	Transit ends (E.S.T.)
Nov. 1 - 2	1	11:18 p.m.	1:35 a.m.
3	1	5:47 p.m.	10:04 p.m.
4	2	7:43 p.m.	10:32 p.m.
10	1	7:43 p.m.	10:00 p.m.
11 - 12	2	10:19 p.m.	1:09 a.m.
14	4	6:25 p.m.	11:12 p.m.
17	1	9:38 p.m.	11:56 p.m.
19	3	in progress at dusk	5:40 p.m.
19	1	in progress at dusk	6:24 p.m.
26*	1	6:03 p.m.	8:20 p.m.
26*	3	6:06 p.m.	9:43 p.m.
29	2	4:49 p.m.	7:40 p.m.
Dec. 1	4	in progress at dusk	5:26 p.m.
3	1	7:59 p.m.	10:16 p.m.
3 - 4	3	10:07 p.m.	1:44 a.m.

*extremely rare combination of events — see text

1 = Io
2 = Europa
3 = Ganymede
4 = Gallisto

Venus

Although the brightest planet is not the most exciting object in the sky this month, it should be your first target for observation no matter what size telescope you use. Venus, low in the southwest, is best observed immediately after sunset. Scan for it with your finderscope. Once located, the planet can be observed with high power — higher than is advised for any other planet — and the image will be more satisfying than that obtained in a dark sky. In addition, Venus is farther from the horizon at sunset thus lessening the degrading effects of atmospheric turbulence.

Small and large telescopes alike will show Venus like a half illuminated ping pong ball during November. The phase decreases from 55 percent illumination on the 1st to 38 percent at month's end. Apparent diameter greatly increases from 22 to 31 seconds of arc during the same period. Distance from Earth on the 1st is 69 million miles and on the 30th, 50 million miles.

Mars

The red planet is in excellent position for telescopic study this month. As the night advances the brilliant planet climbs from low in the east to a dominating position high in the south at about 10 p.m. Mars' magnitude on November 1 is -2.1, but by the 30th it will fade to -1.2. This is the last chance for some years to get such a fine view of our fascinating neighbor world.

By the end of November, Mars will have shrunk to a diameter of 16 seconds of arc compared to 21 seconds of arc in mid-October. For complete tables and hints for observing Mars, see Gazer's Gazette in your September issue.

Saturn

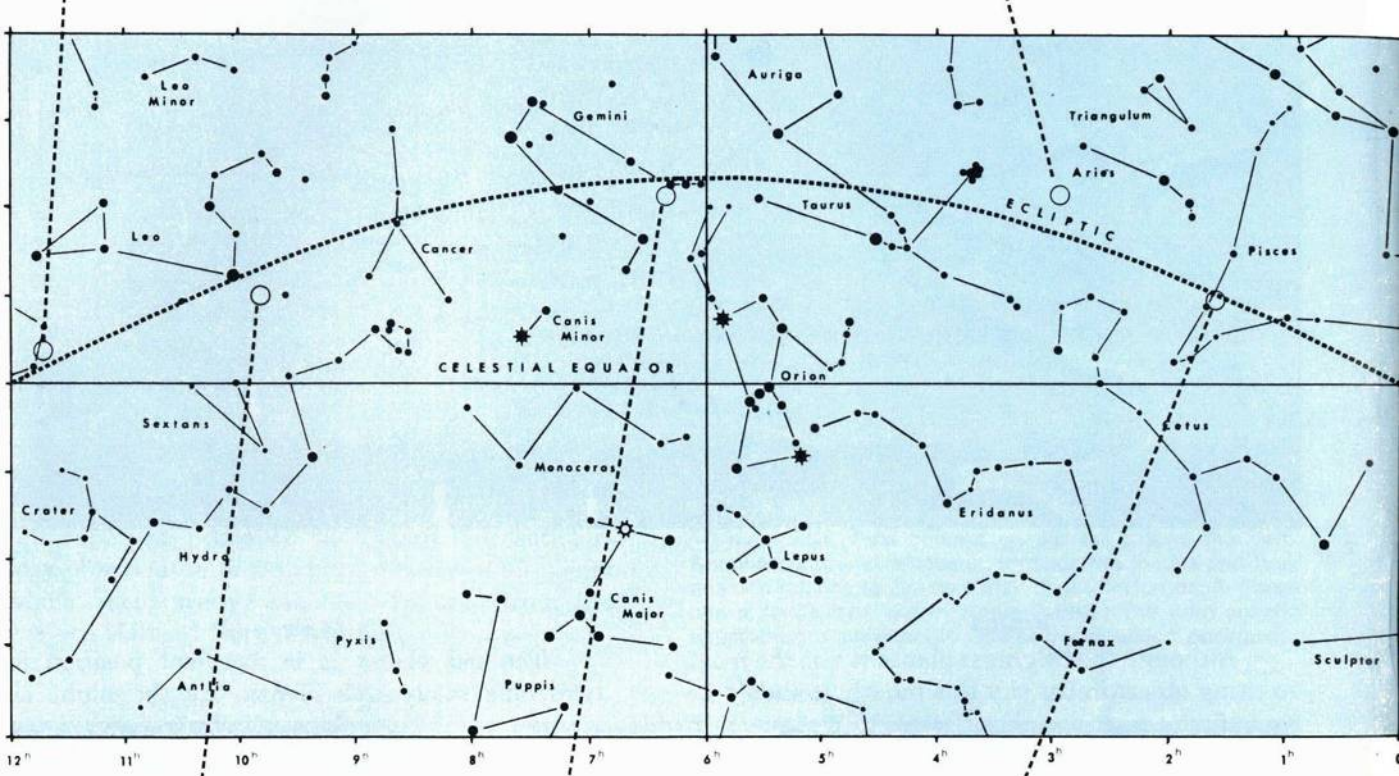
By about 11 p.m. the ringed planet will be high enough above the northeastern horizon to allow convenient telescopic observation. The rings are wide open to our view and present a fascinating sight even in a 2.4 inch refractor. Next month a major article will be devoted to observing Saturn.

FULL MOON
November 10

R.A.	$2^h 57^m$
DEC.	$+ 20°25'$

VESTA

November	1	16
R.A.	$11^h 18^m$	$11^h 42^m$
DEC.	$+ 8°59'$	$+ 7°01'$
DIST.	2.8907A.U.	2.717A.U.
MAG.	+ 8.5	+ 8.3



THIRD QUARTER
November 17

R.A.	$9^h 41^m$
DEC.	$+ 9°20'$

SATURN

November	1	16
R.A.	$6^h 20^m$	$6^h 17^m$
DEC.	$+ 22°16'$	$+ 22°18'$
DIST.	8.4248A.U.	8.240A.U.
DIA.	17.60"	18.1"
MAG.	+ 0.1	0.0

MARS

November	1	16
R.A.	$1^h 51^m$	$1^h 37^m$
DEC.	$+ 9°57'$	$+ 9°36'$
DIST.	0.4546A.U.	0.5104A.U.
DIA.	20.58"	18.3"
MAG.	-2.1	-1.7

This planet finder chart shows the positions of the sun, moon, planets and brighter asteroids for the current month as they appear against the background of the zodiac. Positions are plotted for the 15th with additional ephemerides for the 1st. To find zodiacal constellations visible during the current month, see Star Dome.

Map by Raymond G. Coutchie

FIRST QUARTER
November 3

R.A.	$20^h 48^m$
DEC.	-14°23'

NEPTUNE

November	1	16
R.A.	$16^h 18^m$	$16^h 20^m$
DEC.	-19°48'	-19°54'
DIST.	31.1842A.U.	31.27A.U.
DIA.	2.34"	2.34"
MAG.	+ 7.7	+ 7.7

URANUS

November	1	16
R.A.	$13^h 31^m$	$13^h 34^m$
DEC.	-8°55'	-9°15'
DIST.	19.3779A.U.	19.283A.U.
DIA.	3.54"	3.56"
MAG.	+ 5.7	+ 5.7

JUPITER

November	1	16
R.A.	$20^h 26^m$	$20^h 34^m$
DEC.	-19°58'	-19°31'
DIST.	5.0417A.U.	5.269A.U.
DIA.	36.46"	34.88'
MAG.	-1.9	-1.8

JUNO

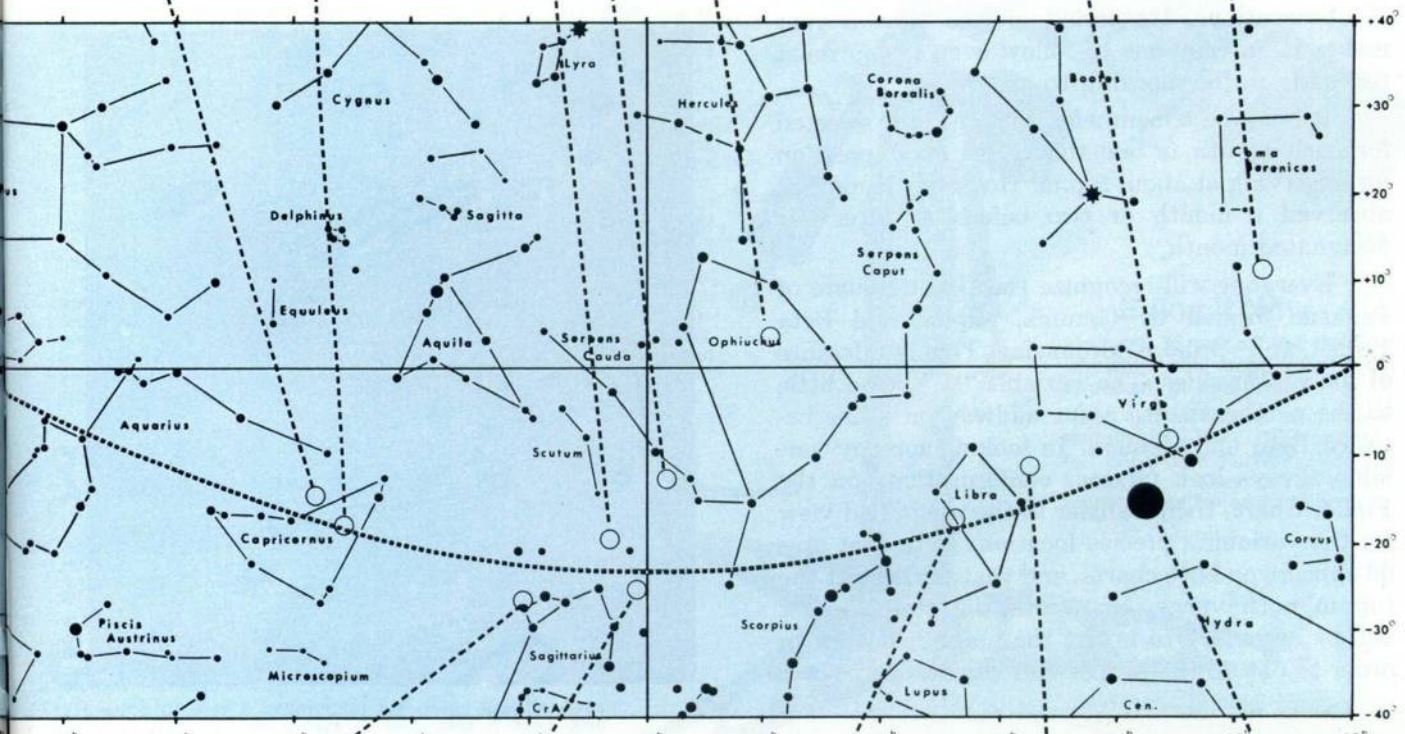
November	1	16
R.A.	$17^h 35^m$	$17^h 55^m$
DEC.	-12°54'	-13°34'
DIST.	3.7011A.U.	3.810A.U.
MAG.	+ 11.6	+ 11.7

PALLAS

November	1	16
R.A.	$16^h 33^m$	$16^h 54^m$
DEC.	+ 5°54'	+ 4°44'
DIST.	3.8501A.U.	3.944A.U.
MAG.	+ 10.4	+ 10.5

PLUTO

November	1	16
R.A.	$12^h 45^m$	$12^h 46^m$
DEC.	+ 12°42'	+ 12°37'
DIST.	31.7830A.U.	31.648A.U.
MAG.	+ 14	+ 14



NEW MOON
October 26

R.A.	$13^h 55^m$
DEC.	-16°21'

MERCURY

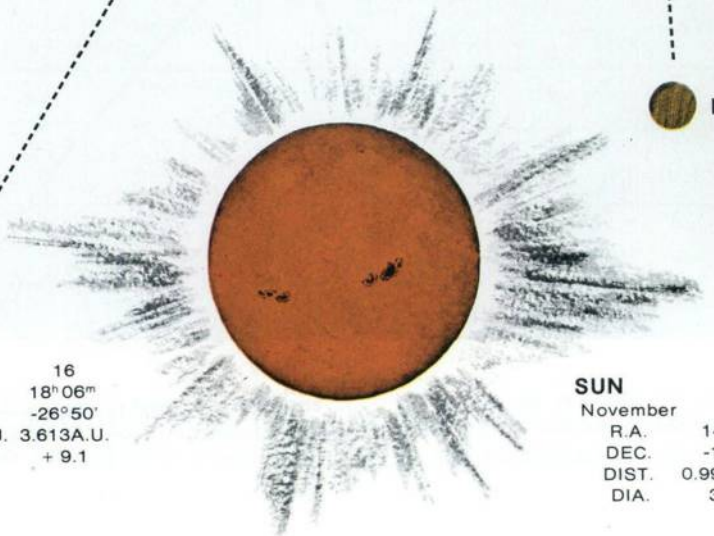
November	1	16
R.A.	$15^h 34^m$	$14^h 40^m$
DEC.	-21°50'	-13°47'
DIST.	0.7627A.U.	0.7361A.U.
DIA.	8.76"	9.08"
MAG.	+ 1.3	+ 1.9

ENUS

November	1	16
R.A.	$17^h 38^m$	$18^h 47^m$
DEC.	-26°35'	-26°25'
DIST.	0.7621A.U.	0.6482A.U.
DIA.	22.08"	25.9"
MAG.	-4.0	-4.1

CERES

November	1	16
R.A.	$17^h 42^m$	$18^h 06^m$
DEC.	-26°30'	-26°50'
DIST.	3.4644A.U.	3.613A.U.
MAG.	+ 9	+ 9.1



SUN

November	1	16
R.A.	$14^h 24^m$	$15^h 24^m$
DEC.	-14°19'	-18°31'
DIST.	0.9924A.U.	0.9888A.U.
DIA.	32'16"	32'24"

November Variable Star

W Pegasi

by

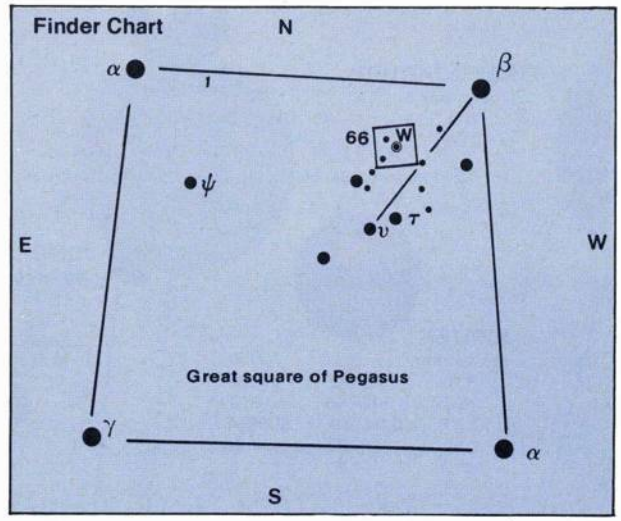
R. Newton Mayall

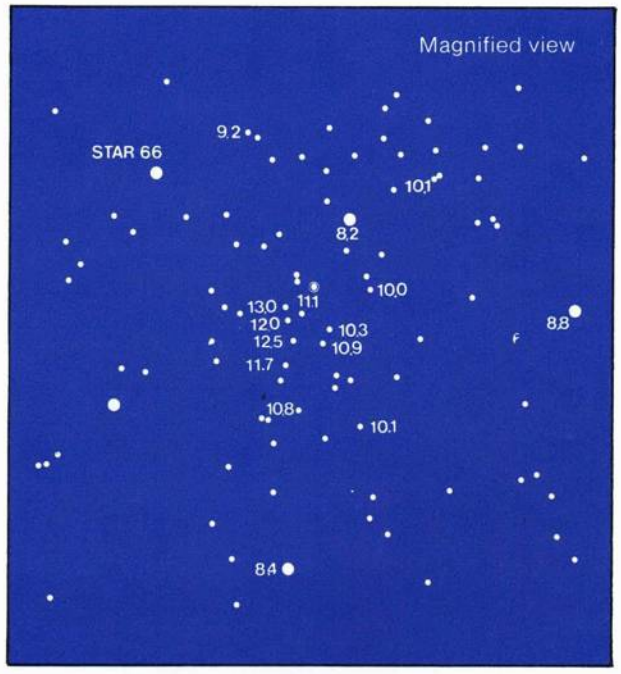
This month's variable star, W Pegasi, shows regular periodicity and varies between 8.2 and 12.7 magnitude at a regular interval of 345 days. Its light curve is generally symmetrical. Sometimes it grows as bright as 7.9 and as faint as 13. A six inch telescope is adequate for observing it throughout its range.

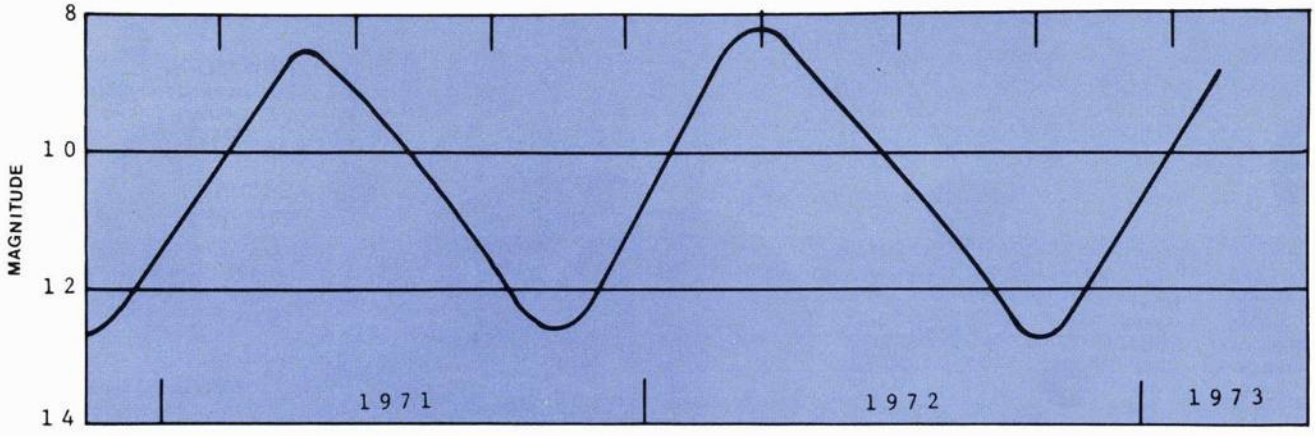
W Pegasi was found to be variable by Thomas Anderson of Edinburgh in 1895, and has been well observed since that time. The light curve shown here was determined from many thousands of observations. Its period of less than a year makes it an easy one to follow even if you must rise early in the morning to observe it.

It must be remembered that the star selected for each month is one that is in good position for observing at about 9 p.m. However, it may be observed a month or two before or after the designated month.

Everyone will recognize the Great Square of Pegasus formed by Gamma, Alpha, and Beta Pegasi, and Alpha Andromedae. This is a feature of the winter skies. The variable "W" lies a little to the northeast of a point midway on a line between Beta and Upsilon. In looking for any variable always look for star configurations on the Finder Chart; then transfer to the magnified view for the variable's precise location. Note that star 66 appears on both charts, and that north is at the top in both views. In a reflecting telescope it will be necessary to invert the magnified view in order to obtain the proper star orientation.







The above light curve shows the 345 day period of the variable star W Pegasi. At its brightest, the star is magnitude 7.9; at its dimmest it is magnitude 13. A telescope with an aperture of at least six inches is necessary to view W Pegasi throughout its range. To locate this variable star see the finder charts above and Star Dome.

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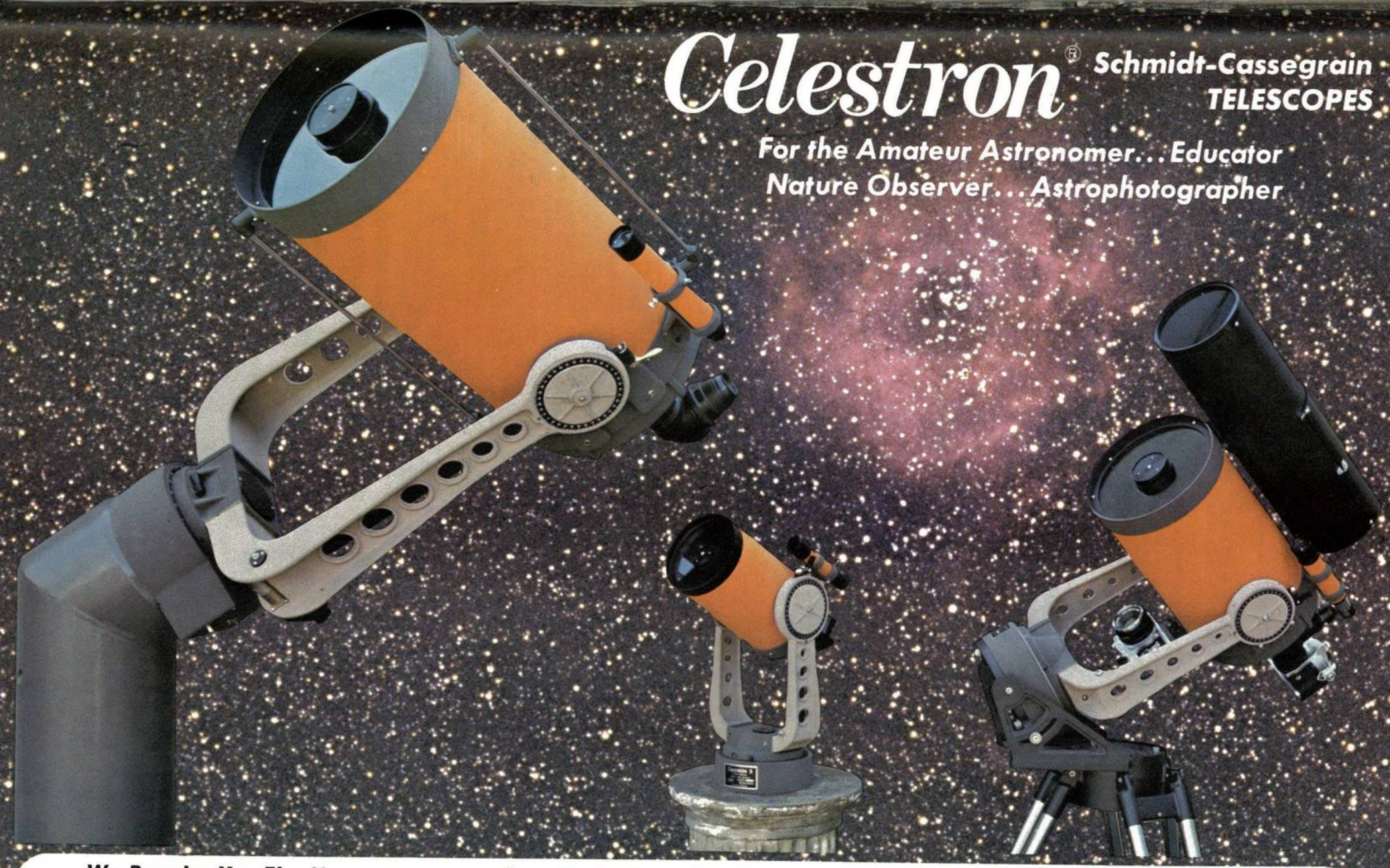

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